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A

DICTIONARY

OF

CHEMISTRY,

Exhibiting the preſent State of the Theory and Practice of that Science, its Application to NATURAL PHILOSOPHY, the PROCESSES OF MANUFACTURES, METALLURGY, and numerous other Arts dependant on the Properties and Habitudes of Bodies, in the MINERAL, VEGETABLE, and ANIMAL KINGDOMS.

WITH A

CONSIDERABLE NUMBER OF TABLES,

Expreſſing the Elective Attractions, Specific Gravities, Comparative Heats, Component Parts, Combinations, and other Affections of the Objects of Chemical Reſearch.

ILLUSTRATED WITH ENGRAVINGS.

By WILLIAM NICHOLSON.

IN TWO VOLUMES.

VOL. I.

LONDON:

PRINTED FOR G. G. AND J. ROBINSON, PATERNOSTER-ROW.

M.DCC.XCV.

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PREFACE.

IT is uſual for Authors to give an account, in a Prefatory Diſcourſe, of the motives which may have induced them to compoſe ſuch works as they preſent to the Public. Apologies for defects, and aſſiſtance to enable the Reader to diſcover excellencies, compoſe no ſmall part of theſe Addreſſes. I have little to ſay in either reſpect. The Bookſeller ſuggeſted to me, ſeveral years ago, his wiſh that I would compoſe a Chemical Dictionary. After ſome deliberation I engaged in the plan, from general as well as particular motives, which it is unneceſſary to ſtate, becauſe ſufficiently obvious. Since that time my progreſs has been interrupted, and at laſt ſuſpended for many months, by misfortunes and ill health; the former of which, though to myſelf an impreſſive leſſon of the bad principles of men in ſociety, is too trite an inſtance of the evils produced by that cauſe, to conſtitute any part of the preſent Diſcourſe. Neither of theſe can be urged in extenuation of the imperfections of the following work; but they are concluſive to juſtify the rectitude of the Author in the mind of ſuch, if any there be, as may ſuppoſe him to poſſeſs the power or the ability to have done better.

The form of a Dictionary, though, for many years, in high eſtimation with the world in books on every ſubject, is confeſſedly inimical to the natural order of things. For this reaſon it ſeems proper to mention its advantages. When a ſubject does not, in itſelf, demand much of arrangement, or if the natural arrangement be ſuch as not to be apprehended but by thoſe who have made conſiderable advances in that department of knowledge, it is evident that the utility of a dictionary to the Learner will more than compenſate for the offence given to the Maſters of the Science. And accordingly it is found that no ſyſtematical arrangement of mere words or terms, with their explanations, can poſſeſs ſo much utility as that which follows the order of the alphabet. When Macquer's Dictionary firſt appeared, the Author remarked that Chemiſtry was little more than a collection of facts, ſcarcely entitled to the name of Science, or capable either of ſynthetic or analytic explanation. Whence he drew a juſt concluſion in favour of the Dictionary form. Since that time, the progreſs of Chemiſtry has, indeed, been uncommonly rapid. But if the Reader will contemplate the numerous blank compartments in the Tables at the

end of this work: if it be moreover conſidered, that the great controverſy among Chemiſts, at preſent, which pervades the whole of the Science, amounts to a confeſſion of ignorance whether in our theoretical explanations we ought to add or ſubtract; that the ſame principles, ſimilar perhaps in all reſpects as to their nature and proportions, produce moſt of the ſtriking differences between organized ſubſtances by the mere order of their combination; that ſcarcely a veſtige of the means to aſcertain this order has yet been diſcerned; that the abſorption, combination, or emiſſion of light, the exiſtence and operation of heat in the latent ſtate, the conducting powers of bodies, their denſities, elaſticities, refractive powers, and various other ſecondary properties, though they muſt all bear relation in ſome way or other to the habitudes which we call chemical, have been little attended to:—if theſe facts be duly conſidered, he will not be diſpoſed to contend with me, when I affirm, that the arguments in favour of the Dictionary form poſſeſs nearly the ſame force, at preſent, as they did when Mr. Keir communicated that valuable maſs of knowledge to the Public.

I have had ſome doubt whether I ought to advert to the Dictionary, of which this eminent Chemiſt has publiſhed a part: I mean the mere commercial conſideration which preſents itſelf between us. When any work is publiſhed, or in progreſs, it may ſeem unfair, that is to ſay wrong, for another Author to bring into the market a work of preciſely the ſame kind. But this rivalſhip in trade, or in literature conſidered as a trade, has always appeared to me to be beneficial to the Public, and conſequently juſtifiable, if conducted in ſuch a manner as not to offend againſt the other univerſal principles which ought to regulate the conduct of every individual. At all events, however, the diſcuſſion of this caſe cannot apply to me. My Dictionary is comprehended within limits ſo much leſs extenſive than thoſe apparently exhibited in the firſt part of Mr. Keir's work, that the departments intended to be occupied by each muſt certainly be very diſtinct. I ſhall therefore diſmiſs this conſideration with the ſincere wiſh, that the world may ſoon be benefited by the farther labours of that Author in his great undertaking.

A leſs equivocal claim of juſtice preſents itſelf with regard to the Authors from whoſe works the following compilation has been, for the moſt part, extracted. I have, on no occaſion, ſcrupled to uſe the very words of the Authors, when the neceſſity of abridgement and interpolation, or the correction of error, have not required me to act otherwiſe. This is certainly the beſt, with regard to utility and accuracy, though it may perhaps be conſidered as a deduction from the Author's own claim to originality. On this laſt head I ſhould have very little anxiety, even if the work were of a different kind; ſtrict truth being of infinitely more value than any other

conſideration.

conſideration. I have, therefore, been led to reject altogether the marks of quotation; but I have not neglected to mention my authorities, wherever it was neceſſary. It will be found, on cloſe examination, that the practice of all Authors who have written on general ſubjects has neceſſarily been the ſame.

Though the Science of Chemiſtry poſſeſſes little of ſyſtem, and it is accordingly found that the writers of general Treatiſes vary greatly in their arrangement of the ſubject, yet it is commonly ſuppoſed that a Dictionary of any Science is, or ought to be, a regular Treatiſe, broken into parts, and diſtributed under the Titles of an Index. A moderate portion of ingenuity will enable any one to ſelect the articles of the following work, and diſtribute them into a kind of ſyſtem. But I will confeſs that I have paid no attention to any ſuch project. To me it ſeems calculated to produce a diſtracting ſet of references from one article to another, and to defeat the very purpoſe of a Dictionary, by requiring the Reader to conſult a great number of articles, when his purpoſe was to ſee under one article the greateſt part of what could be ſaid on that ſubject. I have accordingly endeavoured, as much as the nature of things would permit, to make each article a conciſe Eſſay or Tract upon the ſubject under its title, and have thought it better to make occaſional ſhort repetitions, than oblige the Reader to refer to articles where the relative branches of the ſubject are more fully treated. The great number of references is by this means more naturally ſupplied by thoſe ſhort notices; and the Reader, if his purpoſe require it, will have recourſe to the other articles without formal direction. The Index of Things is obviouſly uſeful for the ſame purpoſe.

A diſtinction is ſometimes made, in experimental Science, between men of theory and men of fact. We are but too apt to run into extremes. The men of theory conſider general reſults as the great and dignified objects of Science, and eſtimate the importance of facts according to their reſpective rank among the illuſtrations of their general theorems. The men of fact, on the contrary, are diſpoſed to attach a high value to the practical department, and are much more attentive to regiſter one incident after another, than to generaliſe and explain the operations they behold. The enlightened cultivator of Science will be neither of theſe excluſively, or rather he will be both. In the acquiſition of knowledge, few men can patiently endure a ſtate of doubt; and there are not many minds ſo cultivated and ſo powerful as to be aware of the ſeductions of a digeſted hypotheſis, which continually preſents its poſſeſſor with imaginary diſcoveries. But the ordinary effects of an attention to hypotheſis are, that things, by frequent repetition, become aſſociated in the mind, which have no real connection in nature; that ſuch events as coincide with the theory make a ſtronger impreſſion on the mind than thoſe

which do not, and accordingly the latter are either overlooked or rejected; and, laſtly, that this falſe coincidence of theory and fact becomes one of the ſtrongeſt arguments in its favour. Hence we ſee, in religious, moral, and metaphyſical controverſies, as well as in thoſe that relate to phyſical objects, converts are ſeldom produced by the direct force of right reaſoning; but in an indirect method, from the repetition of their adverſaries' arguments, with a view to confute them. It ſeems neceſſary, when the mind is thus miſled, that an equal force of habit ſhould be practically generated in favour of the oppoſite ſide of a controverſy, before impartiality can be produced. The man who has been habituated to explain chemical phænomena by the doctrine of phlogiſton, will not be an impartial judge in that controverſy, until he has acquired a facility in explaining them by the doctrine which rejects that principle.

It appears then to be of the utmoſt importance, that every man of Science ſhould acquire ſufficient fortitude to enable him to perceive the narrow limits of his own knowledge, and the numerous objects which require inveſtigation. Vanity may be flattered by the ſpecious pretence of accounting for every thing; but even this principle of ſelf-approbation may be much more highly gratified by the effects of that energy of mind, which is produced by the contemplation of truth, abſtracted from all fiction. More than half of our lives is employed in diſcriminating and unlearning error. How much more effectual would our efforts then be, if, by timely examination and reaſonable doubt, we had continued in the ſituation of being able to receive and apply the truth whenſoever preſented to us! It is affirmed that, in Chemiſtry, even a bad theory is of uſe to methodiſe and arrange facts. But this cannot be true; for bad theory, that is to ſay falſehood, cannot promote the ends of truth: So far as the theory agrees with the truth, it will conſiſt of arrangement growing out of the nature of the facts themſelves; and ſo far as it differs from this, it is deluſion.

Under the impreſſion of theſe and other fundamental principles, I have been diſpoſed to ſet very little value upon the ingenious conjectures preſented to the Public reſpecting the Theory of Chemiſtry by a conſiderable number of men of ability. I have uniformly endeavoured to diſtribute the facts in ſuch a manner that they may tend to explain themſelves; and in the few articles where I have had occaſion to give an account of the theories of others, I have never ſcrupled to diſtinguiſh the weak parts from the ſtrong. Many things are therefore related as matter of doubt, concerning which a large number of Chemiſts entertain no doubt whatever.

In the controverſy reſpecting Phlogiſton, or the nature of Combuſtion, not a little remains to be done, before it can be ſaid that the proceſs is well underſtood. I have aſſerted under the latter article,

that the doctrine which rejects phlogiſton, or a common inflammable matter, appears to me to be much the moſt ſimple, and conſequently probable. But I have not adopted the nomenclature of the Anti-phlogiſtians. We are ſo continually miſled by words that it would, no doubt, be of great advantage if a conſiſtent and uniform nomenclature were generally adopted. The French nomenclature, though not without its faults, appears to be more perfect than any other which has been offered: but I did not think myſelf at liberty to anticipate the public choice, by uſing it in an elementary work.

With regard to the materials, to which I have had recourſe, I do not here enter into any detail. It would be of little uſe to the Beginner, and the Man of Science will ſcarcely need the aſſiſtance of the Index of Names to aſcertain the principal ſources of my information. Thoſe only who may have undertaken the laborious taſk of bringing together, in one maſs, the various facts of a Science ſcarcely methodiſed, which lie diſperſed through the Acts of Academies, Literary Journals, and Treatiſes in various languages, will be truly aware of the probabilities of error or imperfection in ſuch an undertaking. A conſiderable portion of theſe materials muſt in the nature of things be inacceſſible, or unknown, to the Compiler; and the utmoſt induſtry of compilation muſt alſo have its limits. Human undertakings require to be accompliſhed within ſome definite time, otherwiſe their utility would ſuffer from the changes which take place even during the performance. I will not here expreſs any uſeleſs wiſh, that my reſearches had been more fortunate, or my reſources more extenſive. Every man of reflection will do juſtice to my endeavours in this reſpect, and I ought to claim no more.

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A

DICTIONARY

OF

CHEMISTRY.

ABSORBENT. The more ſoluble earths were formerly diſtinguiſhed by the name of abſorbent earths. This diviſion comprehended clay, lime, and magneſia; but modern chemiſts have juſtly rejected it as vague and indefinite.

ABSTRACTION. In the proceſs of diſtillation, the volatile products which come over and are condenſed in the receivers, are ſometimes ſaid to be abſtracted from the more fixed part which remains behind. This term is chiefly uſed when an acid or other fluid is repeatedly poured upon any ſubſtance in a retort, and diſtilled off, with a view to change its ſtate, or the nature of its compoſition. See DISTILLATION.

ACESCENT. A ſubſtance which becomes ſour or acid by ſpontaneous decompoſition, is ſaid to be aceſcent.

ACETOUS. Of or belonging to vinegar, or the acetous acid. See ACID, ACETOUS.

ACHROMATIC. Teleſcopes formed of a combination of lenſes, which in a great meaſure correct the optical aberration ariſing from the various colours of light, are called achromatic teleſcopes. Some of theſe have been made wonderfully perfect, and their excellence appears to be limited only by the imperfections of the art of glaſs making. The artifice of this capital invention of *Dollond* conſiſts in ſelecting, by trial, two ſuch pieces of glaſs, to form the object lenſes, as ſeparate the variouſly coloured rays of light to equal angles of divergence, at different angles of refraction of the mean ray; in which caſe it is evident, that, if they be made to refract towards contrary parts, the whole ray may be cauſed to deviate from its courſe without being ſeparated into colours. The difficulty of the glaſs-maker is

in a great meaſure confined to the problem of making that kind of glaſs which ſhall cauſe a great divergence of the coloured rays with reſpect to each other, while the mean refraction is ſmall. See GLASS.

ACID. In the infancy of any ſcience, when the attention of its cultivators is chiefly employed upon ſubſtances which differ from each other by great and obvious variations, it is eaſy to eſtabliſh criterions, by which the claſſification of bodies may be effected: but when any particular branch is carried to a conſiderable degree of perfection, there will always be found a variety of articles which form a connection between one claſs and another, and render it difficult to draw the line of diſcrimination. Acids were formerly diſtinguiſhed by the popular criterion of taſte which is peculiar to them, and is denoted by the word ſourneſs. Modern diſcoveries have, however, exhibited acids, in which the leading properties are too obſcure to be of any great utility in determining their nature when unknown; and it is only from the general aſſemblage of properties that they can be diſtinguiſhed. Theſe properties are,

1. Their taſte is ſour and corroſive, unleſs diluted with water. 2. They change blue vegetable colours to a red. 3. Moſt of them unite with water in all proportions; and many have ſo ſtrong an attraction to that fluid as not to be exhibited in the ſolid ſtate. 4. At a moderate temperature, or in the humid way, they combine with alkalis ſo ſtrongly as to take them from all other ſubſtances. 5. They combine with moſt bodies, and form combinations attended with many intereſting phenomena; upon the due explanation of which a great part of the ſcience of chemiſtry depends.

There are a conſiderable number of inſtances in which combuſtible ſubſtances are converted into acids by being burned. Thus ſulphur, by combuſtion, affords vitriolic acid; phlogiſticated air, repeatedly ignited by electricity, affords nitrous acid; and phoſphorus, by burning, is converted into phoſphoric acid. The analogy of other facts appears to juſtify the general poſition, that acids conſiſt each of a peculiar baſis, altered by combuſtion; and, as it is now generally admitted that the vital or truly reſpirable part of the atmoſphere is abſorbed during combuſtion, it will follow that an acid conſiſts of a combuſtible ſubſtance united with vital air.

This is indeed the ſimpleſt way of ſtating the reſult. But it is of the greateſt importance, in ſcientific purſuits, to be cautious in ſimplifying our deductions. General hypotheſes are moſt commonly conſtructed, by overlooking ſuch concomitant circumſtances in natural events as are leaſt ſtriking; but which, nevertheleſs, cannot be reaſoned out of the courſe of the actual proceſſes. When this expedient is uſed to obtain a deluſive ſhew of ſimplicity, the buſineſs of enquiring into the phenomena which are exhibited around us, degenerates into a war of words, and the facts are no longer impartially diſplayed; ſuch facts being always eſteemed of greateſt value as ſeem moſt effectual in ſupporting the favourite ſyſtem. It muſt be confeſſed, however, on the other hand, that all uſeful inveſtigation muſt neceſſarily tend to the diſcovery of general truths, and the development of the ſimple laws of nature; that ſyſtems, formed in the leſs perfect ſtate of any ſcience, will of courſe be founded on fewer facts, and will, by ſucceſſive emendation, become more and more complicated; and, conſequently, that the real improvement of any theory will almoſt always conſiſt in the rejection of principles formerly held to be eſſential to the ſcience.

The chemiſts of France conſider combuſtion as a mere union of vital air with any inflammable ſubſtance. Moſt of the chemiſts in England and Germany ſuppoſe one general principle of inflammability, called phlogiſton, to exiſt in all bodies

bodies which are ſuſceptible of burning, and they maintain that combuſtion is a diſengagement of phlogiſton. The diſcovery that vital air is abſorbed in this proceſs, has rendered the ancient theory leſs ſimple. Phlogiſton was formerly a being of great uſe, in ſolving the appearances that take place in all bodies by burning; and its exiſtence was therefore inferred from the facts to which it was applied: but at preſent it embarraſſes the chemiſt in various inſtances, and has been diſpoſed of hypothetically, according to the fancy of the theoriſts. Some affirm, that the vital air combines with the baſe of the combuſtible body, while the phlogiſton is diſengaged and flies off: others aſſert, that vital air unites with phlogiſton only in all caſes of combuſtion; ſo that there are two effective cauſes of this phenomenon; namely, phlogiſton, and air. An acid may therefore be conſidered as compoſed of a combuſtible baſis, united with vital air; or as the ſame baſe, firſt deprived of phlogiſton and then united to vital air; or as a combination of the baſis, together with phlogiſton and vital air, which, in ſome inſtances, the phlogiſtic philoſophers find it neceſſary to ſuppoſe; or, laſtly, if the vital air be aſſumed to be a compounded body, and its parts be ſuppoſed to conſiſt of the general principle of acidity, combined with fire or the matter of heat, it is evident that we ſhall have proceeded ſtill farther into the regions of hypotheſis, and the variety of poſſible arrangements will be greatly multiplied. The writings of modern chemiſts are filled with diſquiſitions founded upon aſſumed combinations of this nature.

Several ingenious attempts have been made to aſcertain the ſtrength of acids, and the real quantity of ſaline matter contained in ſuch as cannot, by any means hitherto deviſed, be deprived of water. Both theſe objects are very difficult to be obtained, and the latter, more eſpecially, does not ſeem to be determinable by any other proceſs than ſuch as ſhall actually leave the acid in a pure ſtate, without the preſence of water or any other ſubſtance. The proſpect of this appears to be ſo unpromiſing as almoſt effectually to diſcourage any attempts at performing it. The former enquiry ſeems to be within our power, provided the determination of the ſtrength of acids be underſtood to imply nothing more than to deduce a method of aſcertaining the quantity of acid, of a given denſity, which may be contained in any given meaſure of the ſame acid, more or leſs diluted with water. Experiments carefully made, by adding certain regulated quantities of water to equal portions of the denſeſt acids, will exhibit a ſeries of denſities or ſpecific gravities, which, being tabulated, will ſerve to indicate the quantities of the denſeſt acid which may be contained in any other portions of the ſame acid examined at the temperature of the original experiments, or with a due allowance for any variation between the temperatures.

The uſual method of aſcertaining the comparative ſtrengths of different acids, conſiſts in ſaturating them with alkaline ſalt; that acid being ſuppoſed the ſtrongeſt which requires the greateſt quantity of alkali to cauſe the total diſappearance of its acid properties. Againſt this, however, it is an inſurmountable objection, that the acids do not differ from each other merely in ſtrength, as eſtimated by this criterion, but are principally diſtinguiſhed from each other by their ſeveral attractions to other ſubſtances, which follow no conſtant law deducible from experiments made with alkalis. So that the acid which requires the greateſt quantity of alkali for its ſaturation, will not maintain the ſame precedence when applied to earths, metals, or combuſtible bodies. As the method of examination by alkalis may nevertheleſs have its uſes, eſpecially in acids of the ſame kind, it is proper to obſerve, that the mineral alkali in pure cryſtals, ſuffered to fall into efflorеſcence, and then dried in ſimilar circumſtances for

a determinate time by the heat of boiling water, is the beſt ſubſtance for affording a conſtant reſult. It muſt be preſerved in a dry bottle well cloſed.

At firſt conſideration it may ſeem an eaſy matter to determine the quantity of acid in any meaſure of fluid, by ſaturating it with alkali, and cryſtallizing the neutral ſalt by evaporating the water. This method muſt be allowed to poſſeſs ſome advantages, though it is preſſed with difficulties of conſiderable magnitude. It is by no means eaſy to aſcertain the quantity of an alkali. The mineral alkali, juſt ſpoken of, contains a large quantity of fixed air, which being pretty conſtant, may not, indeed, prevent the alkali from being uſed to obtain proportional reſults; but it muſt be driven off when the abſolute quantity of alkali is the object of enquiry; and the alkali, thus treated by fire, will in moſt, if not all, caſes diſſolve a portion of the veſſel, and, from its ſtrong tendency to attract moiſture from the air, will be very difficult to be weighed. A careful operator may, however, get over theſe obſtacles, by weighing the earth depoſited during the combination of the alkali with the acid, and this weight of earth being deducted from the weight of the hot alkali, previouſly aſcertained in a cloſed bottle, will leave the real weight of the alkali itſelf: but, after this proceeding, the neutral ſalt will differ in its weight, according to the quantity of water which enters into the formation of its cryſtals; for this quantity will be greater, the lower the temperature at which the cryſtals were formed: ſo that, in the courſe of evaporation and cooling, the cryſtals will contain more and more water, according to the order of their depoſition. The beſt method of rendering the water of cryſtallization a conſtant quantity ſeems to be, to evaporate on a water bath, and let the neutral ſalt ſeparate without expoſing the fluid to the lower temperature.

The acids hitherto diſcovered are diſtinguiſhed according to the mineral, vegetable, or animal kingdoms from which they are obtained. The mineral kingdom affords, 1. the vitriolic acid, known in commerce by the name of oil of vitriol; 2. the nitrous acid, called ſpirit of nitre; 3. the marine acid, called ſpirit of ſalt; 4. the aerial acid, or fixed air; 5. the acid of borax, or ſedative ſalt; 6. the acid of fluor ſpar, or ſparry acid; 7. the acid of amber, or ſuccinous acid; 8. the acid of phoſphorus, or phoſphoric acid; 9. the acid of arſenic; 10. the acid of tin; 11. the acid of molybdena; 12. the acid of tungſten, or wolfram.

The vegetable kingdom affords the acids, 1. of lemons; 2. of apples, or unripe fruits; 3. of galls; 4. of benzoin; 5. of tartar; 6. of ſugar, or ſorrel; 7. of mucilage, or ſugar, by deſtructive diſtillation; 8. of tartar, and 9. of wood, by the ſame proceſs; 10. the acid of camphor; and, 11. the acetous acid, or vinegar.

The animal kingdom affords the acid, 1. of milk; 2. of ſugar of milk; 3. of ants; 4. of Pruſſian blue; 5. of fat; 6. of the ſtone of the bladder; and, 7. of ſilk-worms.

ACID, ACETOUS. Vinegar is an acid, formed by that ſpontaneous change which takes place in organized ſubſtances, and is diſtinguiſhed by the name of fermentation. For the circumſtances and requiſites neceſſary to produce this acid, *ſee* the words FERMENTATION, and VINEGAR. When vinegar is expoſed to diſtillation, a watery fluid firſt riſes, which is ſcarcely acid, but poſſeſſes the lively ſmell of the vinegar itſelf; this is ſucceeded by the acid which chemiſts call the acetous acid, and in commerce is called diſtilled vinegar. The acid reſerved as diſtilled vinegar muſt not exceed two-thirds of the whole, becauſe the action of the heat begins to produce a conſiderable change in the remaining principles on the retort.

Diſtilled

Diſtilled vinegar is much diluted with the water which comes over with it, and theſe two fluids do not ſufficiently differ in volatility to admit of the acid being concentrated, by expelling the water by a graduated heat. A large portion of this water may, however, be ſeparated, by expoſing the fluid to a freezing atmoſphere; for the water congeals firſt, and may then be taken out: the remaining ſtrong acid may be rendered exceedingly pure, by ſeveral rectifications on a water bath, which deprive it of ſuch extraneous and oily parts as may have paſſed over in the firſt diſtillation. At the beginning of the rectification, a very ſpirituous fluid paſſes over, which, being ſeparated and rectified by itſelf, yields a true and fine ether, of a very pleaſant ſmell, and immiſcible with water; which ether may be added to the purified acid of the other rectifications. In this proceſs * it is eſſential to preſerve the phlegm which paſſes over in the firſt diſtillation, becauſe it contains the moſt fragrant parts of the fluid, and ought, therefore, to be added to the reſt of the diſtilled product expoſed to congelation.

The acetous acid obtained in the foregoing proceſs ſeems to be the true concentrated acid, though there may, perhaps, be found reaſons to doubt whether the frequent exhibition of the vaporous form may not have cauſed it to imbibe ſome principle from the atmoſphere. In the other methods of concentrating this acid, there appear ſufficient reaſons to conclude that this really happens: theſe operations conſiſt in combining the diluted or weak acetous acid with an earth, alkali, or metal, and afterwards driving it off by diſtillation from the cryſtallized or dry ſalt. In many, and perhaps moſt inſtances of this kind with acetous acid, the combination is attended with the abſorption of vital air from the atmoſphere, which greatly increaſes the activity of the acid; and accordingly the acid afforded in diſtillation has very different properties from thoſe of diſtilled vinegar, even when both acids are equally diluted: thus the acid called radical vinegar, obtained by diſtillation from the ſaline combination of vinegar and copper, which is improperly called diſtilled verdigriſe, differs greatly from the vinegar made uſe of; and as the combination does not take place, unleſs reſpirable air be abſorbed, it follows from this, as well as other circumſtances, that pure radical vinegar poſſeſſes a higher degree of acidification in conſequence of its having abſorbed vital air.

As the acetous acid has been long known to chemiſts, its combinations with earths, alkalis, metals, and other bodies, will be noticed under the reſpective articles; and for its formation, and the inductions of philoſophers concerning its component parts, *ſee* the word VINEGAR.

ACID, AERIAL. This name was given by Bergman to the acid which is moſt commonly diſtinguiſhed by the name of fixed air. This laſt term, indeed, carries nothing diſtinctive in it, ſince it has been diſcovered that all permanently elaſtic fluids, or airs, may be fixed by combination with other bodies; beſides which, as the qualities of this acid are as often the ſubject of enquiry in its elaſtic as in its fixed ſtate, there is an evident impropriety in the appellation *fixed*; nevertheleſs, as chemiſts are not agreed in the uſe of any other term, we think it proper to conform to the name generally adopted See AIR, FIXED.

ACID OF AMBER. When amber is ſubmitted to diſtillation by a graduated heat in a retort, the products are firſt a reddiſh acid phlegm, which ſmells ſtrongly of the amber; next a volatile acid ſalt, which ſublimes and forms ſmall white or yellowiſh needles that occupy the neck of the retort; this is ſucceeded by a white volatile oil of a pungent ſmell, but which becomes browner, more viſcid, and empyreumatic, as the diſtillation proceeds: and the reſidue is a black, brittle, bitumi-

nous

* Of Lowitz. See Kier's Dictionary, p. 32.

nous maſs. It is the white ſublimed ſalt which is diſtinguiſhed by the name of the acid of amber, and requires to be further purified by repeated ſolutions and cryſtallizations. A pound of amber does not afford more than half an ounce of this ſalt.

The acid of amber is ſoluble in twenty-four times its weight of cold water, and in a much leſs quantity when boiling hot. Boiling ſpirit of wine takes up more than one-third of its weight, of which a conſiderable portion ſeparates in cryſtals by cooling. Vitriolic acid diſſolves it, as do likewiſe the nitrous, marine, acetous, and regaline acids, by the aſſiſtance of heat; but it may be again ſeparated from them without alteration. Mere heat ſublimes it at a higher temperature than raiſes the volatile alkali. The addition of nitre cauſes it to detonate, but the aerial products of this detonation have not been aſcertained.

The acid properties of this ſalt are exhibited by its taſte, by its giving a red colour to litmus, or heliotropium, and to ſyrup of violets, and alſo by its combining with alkalis, earths, and metallic calces, with which it forms peculiar ſaline compounds.

When a ſolution of vegetable alkali is ſaturated with the acid of amber, and ſlowly evaporated, it affords a neutral ſalt in white tranſparent cryſtals, which have a bitter taſte, are eaſily ſoluble in water, and deliqueſce in the air: in the fire they decrepitate and melt, but the acid is not driven off, unleſs perhaps by a very ſtrong heat. The neutral ſalt formed in the ſame manner with this acid and the mineral alkali poſſeſſes nearly the ſame properties, excepting that they do not attract humidity when expoſed to the air. The combination of volatile alkali with acid of amber ſhoots into needle-formed cryſtals, which deliqueſce in the air, evaporate totally when heated in a ſilver ſpoon, and ſublime entire by heat in cloſed veſſels.

Lime and ponderous earth both form ſalts of very ſparing ſolubility with this acid: magneſia forms with it a white ſaline maſs of a gummy conſiſtence, which becomes yelloviſh when dried by the fire, but afterwards attracts moiſture from the air. Clay and the acid of amber form a ſalt in priſmatic cryſtals.

The various experiments neceſſary to aſcertain the habitudes of the acid of amber with metals have not been yet made and duly verified. Gold and platina have not been tried. Silver is not acted upon in its metallic ſtate; but if it be previouſly diſſolved in another acid, and precipitated by the addition of an alkali, the precipitate will combine with the acid of amber, with which it forms long thin cryſtals, which part with their acid to alkalis, and alſo to ſilver and copper. Copper, in its metallic ſtate, forms with the acid of amber a green ſolution that affords cryſtals. Lead is not acted upon in the metallic ſtate; but its precipitate by alkalis is diſſolved, and affords cryſtals: the lead may be precipitated from this ſolution in the metallic form, by the addition of zinc, or in the form of a grey calx, when an alkali is added. Iron and its precipitates are diſſolved in this acid, and the latter afford cryſtals. Tin is taken up, but falls again in the form of a white calx. The precipitate of this metal from an acid by an alkali is alſo ſoluble in acid of amber, and affords, by evaporation, broad, foliated, tranſparent cryſtals. By digeſting the precipitate of mercury by an alkali, for ſome days, in acid of amber, a ſhapeleſs ſaline maſs is obtained, from which the mercury is precipitated in very ſmall quantities by alkali, copiouſly by liver of ſulphur, and in its metallic ſtate by copper. Zinc is readily diſſolved in its metallic ſtate by this acid: the ſolution of precipitate of zinc, obtained by alkalis, affords cryſtals. Biſmuth, and its precipitate by alkalis, are likewiſe ſoluble, and the latter cryſtallizable. None of the known

metallic combinations of this acid are deliqueſcent, and they all give out their acid by diſtillation.

For the order of the attractions of this acid, *ſee* ATTRACTION, ELECTIVE.

ACID OF ANTS. Theſe inſects contain an acid, which they either diſcharge when irritated, or moiſten their fangs with it, to render their bite more painful: it may be obtained from the ants, either by ſimple diſtillation, or by infuſion of them in boiling water, and ſubſequent diſtillation of as much of the water as can be brought over without burning the reſidue: it may be purified either by repeated rectifications carefully managed, or by boiling to ſeparate the impurities; or it may, after rectification, be concentrated by froſt, which ſeparates part of its water in the form of ice. If it be ſaturated with fixed alkali, then filtered, evaporated, and diſtilled with half its weight of concentrated vitriolic acid, a very clear ſtrong acid comes over. The acid of ants obtained in this way may, however, with great juſtice, be ſuſpected of having ſuffered a change in its properties, of the ſame nature as that which vinegar is ſubject to, when converted into radical vinegar by a like proceſs. (See page 5.)

The acid of ants exhibits all the uſual criterions of acidity, ſuch as reddening blue vegetable colours; it renders the vitriolic acid black, and gives the yellow colour and fuming quality to pale nitrous acid. When diſtilled with ardent ſpirit, it affords ſome indications of an ethereal product; and the concentrated acid, obtained from its alkaline combination with alkalis, affords a large proportion of ether with ardent ſpirit. This appears to ſhew that the latter acid is altered by the proceſs it has undergone, during which it probably becomes more completely acidified, by abſorbing a greater portion of vital air.

The acid of ants unites with fixed vegetable alkali and forms a neutral ſalt in deliqueſcent cryſtals, from which the acid may be driven by heat, though not in its entire ſtate; for the heat requiſite for that purpoſe is ſo great, that the acid is decompoſed, and affords fixed air and inflammable air. With mineral alkali this acid forms a very ſoluble, cryſtallizable, deliqueſcent ſalt, which is ſuſpended in twice its weight of water: its combination with volatile alkali is ſo greedy of water, that it cannot be exhibited in the cryſtalline form but with great difficulty.

Acid of ants, combined with lime, affords permanent cryſtals ſoluble in eight times their weight of water, and of a bitter taſte; magneſia is attacked by it, and forms an inſipid cryſtalline ſalt, ſoluble in thirteen parts of water. Ponderous earth afforded permanent cryſtals, ſoluble in four parts of water; and pure clay, or earth of alum, unites with difficulty with it. None of theſe combinations are ſoluble in ardent ſpirit.

This acid diſſolves iron and zinc very readily, but its action on copper is weak: it ſcarcely acts at all upon ſilver, lead, tin, regulus of antimony, biſmuth, mercury, arſenic, cobalt, nickel, and gold, but it diſſolves their calces: it does not act upon the calx of platina. The ſalts formed by the calces of ſilver, copper, lead, biſmuth, and mercury, are cryſtallizable.

ACID OF APPLES. The acid which abounds in ſour or unripe fruits exhibits diſtinct properties: as it is plentifully obtained from apples, the firſt examiner, Scheele, has denominated it the Acid of Apples. In order to obtain it, the juice of ſour apples is expreſſed from the fruit, and ſaturated with vegetable alkali. To this liquor a ſolution of the vitriolic ſalt of lead muſt be very gradually added: a double decompoſition takes place; the vitriolic acid combines with the alkali, and forms vitriolated tartar, at the ſame time that the acid of apples, uniting with the lead, forms an inſoluble precipitate. When the

pre-

precipitate nearly ceaſes to fall down, the ſolution of vitriol of lead muſt be added cautiouſly, a drop at a time, until no more precipitate is afforded: the vitriolated tartar may be waſhed off from the precipitate; and diluted vitriolic acid being then poured on the precipitate, ſugar of lead is again formed, and the acid of apples is ſet at liberty.

In ſuch fruits as contain the acid of lemons, as well as that of apples, the ſeparation of one from the other is accompliſhed by the following proceſs: The juice of gooſeberries, for example, is evaporated to the conſiſtence of ſyrup; pure ardent ſpirit being poured upon this, diſſolves the acids, and leaves the mucilage, which may be ſeparated by filtration: the ardent ſpirit being then evaporated, and water added, the acids muſt be ſaturated with chalk. The ſolution being boiled for a few minutes, the calcareous ſalt of lemons falls to the bottom, on account of its difficult ſolubility, while the other ſalt, conſiſting of the acid of apples united to lime, remains ſuſpended, and may conſequently be decanted off. This neutral ſalt not being ſoluble in ſpirit of wine, may be precipitated by the addition of a proper quantity of that fluid, which, at the ſame time, deprives it of a portion of ſaponaceous and ſaccharine matter. The coagulum, or precipitate, which conſiſts for the moſt part of the acid of apples, perfectly neutralized by lime, may be diſſolved in boiling water. An addition of ſugar of lead forms a precipitate by double affinity, as in the firſt caſe, conſiſting of the acid of apples united to lead; and this waſhed precipitate may be decompoſed by the addition of diluted vitriolic acid, which combines with the lead, and ſets the acid of apples at liberty.

This acid exhibits peculiar properties: it cannot be obtained in cryſtals, and forms deliqueſcent ſalts with the three alkalis, and alſo with magneſia. Its ſaline combination with lime is cryſtallizable; and with clay it forms a ſalt of very ſparing ſolubility: it diſſolves iron, with which it forms a ſalt that does not cryſtallize; with zinc it forms a ſalt which affords beautiful cryſtals. It precipitates the nitrous ſolutions of mercury, lead, ſilver, and gold, in the metallic ſtate. When nitrous acid is repeatedly diſtilled from it, it is converted into acid of ſugar.

ACID OF ARSENIC, *or* Arsenical Acid. The earlier chemiſts were embarraſſed in the determination of the nature of the white ſublimate which is obtained during the roaſting of cobalt and other metallic ores, known in commerce by the name of arſenic: its ſolubility in water, its power of combining with metals in their reguline ſtate, together with other apparently heterogeneous properties, rendered it difficult to determine whether it ought to be claſſed with metals or ſalts. Subſequent diſcoveries have ſhewn the relation it bears to both: when treated with combuſtible matter, in cloſe veſſels, it ſublimes in the metallic form; combuſtion, or any analogous proceſs, converts it into a calx; and when the combuſtion is carried ſtill further, by the application of nitrous acid, the arſenical baſis becomes itſelf converted into an acid.

We are indebted to the illuſtrious Scheele for the diſcovery of this acid, which may be obtained by various methods. Two ounces of the white calx of arſenic, reduced to powder in a glaſs mortar, are to be put into a tubulated retort, likewiſe of glaſs: upon this ſeven ounces of pure marine acid, of the ſpecific gravity of 125, muſt be poured; the mixture muſt then be heated until the arſenic is diſſolved, and then, while the ſolution is ſtill warm, three ounces and a half of pure nitrous acid, of the ſame ſpecific gravity, are to be added, together with what marine acid may have come over into the receiver; the receiver may then be again applied, but not luted, and the diſtillation continued. The mixture froths and emits red nitrous fumes, part of which are condenſed in the receiver in coloured

or phlogiſticated nitrous acid. As ſoon as, in the progreſs of the operation, the red vapours have ceaſed to appear, an ounce of finely powdered arſenic is to be again added, and the ſolution effected as before, by a gentle ebullition. To this an ounce and a half of freſh nitrous acid muſt be added, which will produce a ſecond effervescence and diſcharge of red vapours: the diſtillation muſt now be continued to dryneſs, and the fire muſt be urged towards the end, to ſuch a degree as to make the reſidual white maſs thoroughly red hot. This maſs is the dry acid of arſenic, which may either be preſerved in that form in a cloſed veſſel, or may be diſſolved by boiling it for a few minutes in twice its weight of diſtilled water. The ſolution, after ſubſidence, or filtration through blotting paper, previouſly waſhed in hot water, is the liquid acid of arſenic.

This proceſs conſiſts in nothing more than a judicious application of nitrous acid to the white arſenic, which it acidifies either by the communication of vital air, the abſtraction of phlogiſton, or perhaps by both; but, in a word, by effecting the ſame change as is produced by combuſtion, whatever may be the theory of that proceſs. As the white arſenic is ſcarcely ſoluble in nitrous acid, and as the violent effervescence produced by adding aqua-regia, or a mixture of marine and nitrous acid, to this ſubſtance, is found to throw the powder up to the ſurface before ſolution can take place, it is evidently moſt convenient to divide the arſenic, by previous ſolution in marine acid, in order that the nitrous acid may with facility act upon all its parts. This appears to be the uſe of the marine acid. The ignition at the end of the operation ſerves to drive off the adventitious acids which might remain together with that of arſenic; and from this circumſtance it is ſeen how much more fixed the arſenical acid is than the calx itſelf. This acid, which appears to be ſcarcely, if at all, leſs poiſonous than arſenic itſelf, has no taſte when perfectly dry; which ſeems to ariſe from its not readily combining with water, though it is ſoluble in a ſmall proportion of that fluid, and even attracts it from the atmoſphere, and deliqueſces in proceſs of time. The glaſs retort is much corroded during this operation, and the acid, after ſolution in water, depoſits an earth which is found to be ſiliceous. It is not clear, however, from this circumſtance, that the dry arſenical acid diſſolves ſiliceous earth, becauſe the glaſs may, with equal probability, be ſuppoſed to ſuffer decompoſition by virtue of a ſuperior affinity between the alkali of the glaſs and itſelf.

The inventor likewiſe converted arſenic into an acid by means of manganeſe. This metallic calx is known to be capable of affording vital air during any proceſs, by which it is brought nearer to the metallic ſtate: it therefore produces, in many bodies to which it may be properly applied, changes ſimilar to thoſe effected by combuſtion; that is to ſay, according to the ancient theory, it dephlogiſticates them. If one part of powdered manganeſe be mixed, in a tubulated retort, with three parts of the above deſcribed marine acid, the veſſel being of ſuch a ſize as that the mixture ſhall occupy one fourth of its capacity; and if one fourth of white powdered arſenic, with the addition of one eighth of diſtilled water, be put into a receiver, which is then to be luted on, and diſtillation be effected by a ſand heat, the manganeſe will convert the marine acid into that aeriform fluid, which is known by the name of dephlogiſticated marine acid. This acid will be abſorbed by the water in the receiver, where it will produce an effect upon the arſenic, of the ſame nature as that which itſelf ſuſtained in the retort from the manganeſe, that is to ſay, it will dephlogiſticate it, or communicate that vital air which is neceſſary to convert it into an acid. During the courſe of ſome hours the arſenic will be diſſolved, and two different liquid ſtrata, which will not mix together, will be perceived in the re-

ceiver. This ſolution may now be put into a clean glaſs retort, and diſtilled to dryneſs by a fire which muſt be raiſed to ignition at the end of the proceſs. In this operation, likewiſe, two different liquids paſs over into the receiver, and do not unite together. A white maſs remains in the retort, which is the acid of arſenic.

The two different liquids are ſtated by Scheele to conſiſt of liquid butter of arſenic, and ſolution of arſenical acid: for the dephlogiſticated, or aerated marine acid, which comes over in the operation with manganeſe, acidifies part of the arſenic in the receiver, and is itſelf by that means again converted into common marine acid, which diſſolves a portion of the arſenic that yet remains unchanged. This laſt ſolution being much heavier than the other, occupies the lower place.

The arſenical acid was likewiſe obtained more than forty years ago, by the celebrated Macquer, who ſuppoſed it to be mere arſenic. Pelletier has repeated the proceſs, by mixing white arſenic with the ſaline combination of nitrous acid and volatile alkali, and diſtilling the mixture. Fuming nitrous acid firſt paſſes over, and afterwards the volatile alkali, while the arſenic is left behind in the ſtate of an acid.

The white calx of arſenic gains about one ninth of additional weight by being converted into an acid: this, however, muſt vary, if it ſhould appear, upon experiment, that the calx of arſenic is not always accurately in the ſame ſtate.

The acid of arſenic is again reduced by treatment with inflammable matter. If one ounce of dry acid of arſenic be expoſed to a temperature nearly approaching to ignition, it flows into a clear liquid, which when cold is of a milky colour; but if the heat be raiſed to ſuch a degree as to ſoften the glaſs retort, the acid begins to boil, and a ſublimation of arſenical calx takes place, which continues as long as the ebullition is kept up. In the experiment of Scheele, the acid was loſt by the melting of the retort at the end of half an hour: the ſame quantity of dry acid of arſenic was diſſipated by heat in an open crucible in a quarter of an hour, probably becauſe the heat was greater. The vapours received under a glaſs veſſel conſiſted in the white calx of arſenic, and not the arſenical acid. A ſmall quantity of clear glaſs, difficultly fuſible, remained in the crucible, and was found to conſiſt of clay and arſenical acid. In the humid way, the arſenical acid is not affected by digeſtion with charcoal; but if the mixture be put into a retort, and the moiſture driven off by heat, which is afterwards to be increaſed until a low ignition is produced, the maſs at this laſt period takes fire ſuddenly, the whole of the acid being reduced and ſublimed into the neck of the retort. Moſt of this product conſiſts of the regulus, or arſenic in the metallic ſtate, the reſt conſiſting of the white calx of arſenic with powder of charcoal, no doubt raiſed before the complete reduction had time to take place. No veſtige of acid is found in this operation, but a few drops of water are found in the receiver, which muſt not be applied until the whole of the moiſture of the original mixture has been diſſipated. This experiment ſucceeds equally with the arſenical acid prepared by means of manganeſe. After ſome days digeſtion of the acid of arſenic with oil of turpentine, unctuous oil, and ſugar, the mixture becomes thick and black; and if ſome marine acid be abſtracted from this by a gentle heat, it is found to contain arſenic, or the white calx, as is proved by the addition of a ſmall portion of nitrous acid, and diſtillation, according to the firſt proceſs for obtaining the acid of arſenic. Spirit of wine is not changed either by digeſtion or diſtillation with the acid of arſenic. One part of ſulphur digeſted with ſix of this acid ſuffers no change; but when the mixture is evaporated to dryneſs, and diſtilled in a glaſs retort with a receiver,

a ſudden and almoſt inſtantaneous combination takes place at the heat which melts the ſulphur. The whole maſs riſes at once in the form of a red ſublimate, and a volatile ſulphureous acid is found in the receiver.

The foregoing experiments may in general be explained upon the common principles of thoſe reductions by which calcined or burned bodies have their ſtate of combuſtibility reſtored; that is to ſay, by the tranſmiſſion of the principle of inflammability, or phlogiſton, from ſome other combuſtible body, or the extrication of vital air, which is either volatilized, or transferred from the reduced ſubſtance to that which is employed in the reduction. Theſe theories correſpond with the reduction of arſenical acid into the metallic ſtate by heating it with charcoal; the phlogiſton of the charcoal being either transferred to the arſenical acid, which it reduces at the ſame time that the charcoal becomes burned; or otherwiſe, the effect being produced ſimply by the tranſmiſſion of vital air from the arſenical acid to the charcoal; or thirdly, by a mutual transfer of both theſe principles, according to ſuch chemiſts as find ſufficient reaſon to combine the theory of Stahl with that of the moderns. The firſt experiment, however, in which the arſenical acid is reduced by mere heat in a cloſed veſſel, is not ſo eaſily explained according to the doctrine of phlogiſton. The great diſcoverer of this acid, Scheele, retaining the doctrine that combuſtion is occaſioned by the tranſmiſſion of a principle of inflammability, was driven to the concluſion, from this fact, and others of the like nature, that mere heat contains that principle, and that, in the preſent inſtance, the arſenical acid becomes reduced by virtue of a decompoſition of the matter of heat, one of whoſe principles, namely, phlogiſton, was ſuppoſed to combine with and revive the arſenical acid. To thoſe who conſider the exiſtence of a matter of heat as neither proved nor probable, and who even, if inclined to admit that exiſtence, might ſtill be diſpoſed to doubt whether it were compounded, and of what parts, the explanation of Scheele will probably appear raſh and embarraſſed; and to ſuch the explanation of the modern theory will be attended with peculiar felicity. In this theory, the arſenical acid being taken to conſiſt of vital air united with the metal, arſenic is reduced ſimply by the expulſion of that vital air by heat; a phænomenon by no means ſingular, and which indeed only requires the teſt of experiment in the preſent inſtance, to conſtitute one of the ſtrongeſt arguments in its favour.

In the laſt experiment with ſulphur it appears that this ſubſtance is not diſpoſed to combine with arſenic, unleſs it be conſiderably reduced. During this proceſs, part of the ſulphur is therefore burned, and converted into volatile vitriolic acid, either by the abſorption of part of the vital air of the arſenic, or by the communication of a portion of its phlogiſton.

Acid of arſenic, ſaturated with fixed vegetable alkali, by the teſt of the ſolution of lacmus, produces a neutral deliqueſcent ſalt, which cannot be reduced to cryſtals: but if as much acid be added as ſhall enable the ſolution to redden lacmus, and produce no change upon ſyrup of violets, the ſolution will afford fine cryſtals. When this ſalt was urged by a ſtrong heat for an hour, in a crucible upon which another was luted, and the whole was ſuffered to grow cold, the inſide of the crucible was found covered with a white glazing, but the remaining ſalt, when examined by ſolution and cryſtallization, was found to poſſeſs the ſame exceſs of acid as before. This cryſtallized ſalt being expoſed to a red heat in a crucible, with one eighth of its weight of charcoal powder, boiled violently, and a very fine regulus of arſenic was ſublimed: the reſidue was alkaline, and exhibited no trace of the arſenical acid.

The mineral alkali, when perfectly ſaturated with arſenical acid, forms a cryſtallizable ſalt reſembling that laſt mentioned. If an exceſs of acid be added, the ſalt proves deliqueſcent, and does not cryſtallize.

Volatile alkali, ſaturated with the arſenical acid, affords a ſalt in cryſtals reſembling the foregoing: it loſes its tranſparency by heat, which diſſipates the volatile alkali. This ſalt comes over in the fluid ſtate, after which the reſidue melts, and arſenic is ſublimed: a white maſs remains, which likewiſe melts in a ſtronger heat, and proves to be the acid of arſenic. During this proceſs a diſengagement of that peculiar fluid, which is known by the name of phlogiſticated air, takes place juſt as the arſenic is ſublimed. It appears, therefore, that the firſt heat diſengages part of the volatile alkali; but that the laſt portion of the volatile alkali adheres ſo ſtrongly to the acid of arſenic, as to remain until the heat has become ſufficient to decompoſe it into its component parts, which, from other experiments, are known to be inflammable air and phlogiſticated air. The phlogiſticated air flies off, while the inflammable air affords phlogiſton to a portion of the acid, which then ſublimes in the form of the white calx; or otherwiſe, according to the antiphlogiſtic theory, the inflammable air unites with a portion of the vital air of the arſenic, which thus becomes reduced. The conjunction of theſe two airs is ſaid to form water, though Dr. Prieſtley has rendered that poſition ſomewhat doubtful. See VOLATILE ALKALI; and alſo WATER.

The acid of arſenic does not take the alkali either from vitriolated tartar or Glauber's ſalt, in the humid way; in the dry way it decompoſes both, but the former requires a ſtronger heat than the latter. One part of purified nitre being diſtilled with three parts of acid of arſenic, the humidity of the maſs paſſed over firſt, after which followed nitrous acid; the reſidue contained the neutral arſenical ſalt of Macquer, and ſome undecompoſed nitre. Common ſalt, diſtilled with three times its weight of arſenical acid, was in part decompoſed: a portion of marine acid paſſed over into the receiver, and the reſidue conſiſted of common ſalt and marine alkali ſuperſaturated with acid of arſenic. One part of ſal-ammoniac was diſtilled with three parts of acid of arſenic: marine acid with water firſt came over; this was followed by a more concentrated marine acid, at the ſame time that the remaining maſs entered into fuſion. Immediately afterwards a white ſmoke filled the retort, a white powder was ſublimed, a pungent volatile alkali paſſed over into the receiver, and a reſiduum of arſenical acid was left in the retort: the white powder which aroſe proved, upon examination, to conſiſt of ſal-ammoniac, with a portion of calx of arſenic. Upon a repetition of the experiment, with a bladder applied inſtead of a receiver, it was found that phlogiſticated air was extricated at the time the ſublimate roſe: from which circumſtance it follows, that part of the acid of arſenic firſt combined with part of the volatile alkali of the ſal-ammoniac, and cauſed the diſengagement of marine acid; that when the heat was increaſed, the ſal-ammoniac was ſublimed, and ſoon afterwards the volatile alkali, and a portion of phlogiſticated air from that part of the volatile alkali which afforded inflammable air to revive the arſenic, which was driven up nearly at the ſame time. The theories of the revivification of the arſenic have already been ſufficiently inſiſted on.

Gypſum, or ſelenite, mixed with two parts of dry acid of arſenic, gave out vitriolic acid by a red heat, and the remainder fuſed into an opake milky glaſs. Ponderous ſpar, or the combination of vitriolic acid and ponderous earth, produced nearly the ſame appearances, though with a ſtronger heat. Twelve parts of acid of arſenic are required to decompoſe one of fluor ſpar. The ſparry acid comes over together with ſiliceous

ſiliceous earth, which it takes from the glaſs, and depoſits as it comes in contact with water placed for that purpoſe in the receiver.

When acid of arſenic is dropped into lime-water, it forms a combination with that earth which falls down, but is again diſſolved if more acid be added. This ſolution affords ſmall cryſtals by evaporation. The vitriolic acid takes the lime from a ſolution of theſe ſalts. The precipitate of lime, combined with the acid of arſenic, forms a thick flux after ſtrong calcination for an hour in a covered crucible, but it ſtill retains the acid. When equal meaſures of this calcareous ſalt and charcoal powder are expoſed to ſtrong heat in a retort, a ſhining regulus is ſublimed, and the reſidue conſiſts of quicklime mixed with charcoal and ſome arſenic.

Magneſia is ſoluble in the arſenical acid, but coagulates near the point of ſaturation. If the fluid be evaporated when the quantity of magneſia is not ſufficient to form the coagulum, it grows gelatinous, and the gelatinous part does not afford cryſtals by ſolution in water and evaporation. The phænomena of this magneſian ſalt, in the dry way, with charcoal, nearly reſembles thoſe of lime in ſimilar circumſtances.

Pure clay, or the earth which is precipitated by vegetable alkali from a ſolution of alum, is eaſily ſoluble in the acid of arſenic, but coagulates as ſoon as it arrives at the point of ſaturation: its acid is not driven off by mere heat. If the ſolution of this neutral ſalt be evaporated to dryneſs, and then mixed with a little charcoal powder, and expoſed to diſtillation with a ſtrong heat, a ſmall quantity of yellow ſublimate riſes into the neck of the retort, and likewiſe ſome ſhining regulus, at the ſame time that volatile ſulphureous acid paſſes over into the receiver: the reſiduum does not appear to be pure clay, for it is difficultly ſoluble in vitriolic acid, with which, however, it forms ſome alum in the ſpace of two months. The acid of arſenic acts very ſparingly upon common white clay in the humid way, but theſe ſubſtances unite in a ſtrong red heat.

The precipitation afforded by adding vitriolic acid to the liquor of flints was not at all acted upon by the acid of arſenic, either in the humid or dry way.

Ponderous earth is readily diſſolved in the acid of arſenic, but the combination precipitates as ſoon as it has arrived at its point of ſaturation. This ſalt exhibits the ſame appearances in the dry way as the combinations of arſenical acid and lime.

The acid of arſenic being applied to the filings of the metals, in a long-necked flaſk, to prevent its reduction, acts upon ſeveral of them in a digeſting heat. Gold and platina are ſcarcely acted upon. Silver is not attacked by digeſtion; but when the acid comes to be fuſed, the metal is diſſolved, and affords a colourleſs glaſs, which is nearly tranſparent; ſoluble in water, with the loſs of greateſt part of the ſilver, which ſubſides in the form of a brown powder, containing a minute portion of the acid, and reducible, like the other precipitates of ſilver, by mere heat. Mercury is not attacked by the arſenical acid, in the heat of digeſtion; but when the acid and mercury are urged in a retort, by an heat which is near melting the veſſel, part of the mercury combines with the acid, and forms a yellowiſh maſs of extremely difficult fuſion, very fixed, and ſoluble in water. Diluted nitrous and vitriolic acids have ſcarcely any effect on it, but marine acid readily diſſolves it. This ſolution, by evaporation to dryneſs, and diſtillation, affords corroſive ſublimate, and the reſidue is arſenical acid: whence it follows, that the mercury in the arſenical combination muſt have been perfectly calcined. Copper is diſſolved by the arſenical acid in digeſtion, and affords a green ſolution. One part of copper filings, mixed with two of dry arſenical acid, affords a blue

maſs

maſs by fuſion, at an elevated degree of heat, which is ſoluble in water; and then proves to be the ſame combination as was produced by digeſtion. The watery ſolution lets fall a light blue powdery matter, conſiſting of a combination of copper with arſenical acid. Iron likewiſe is attacked by this acid during digeſtion, and the whole ſolution at laſt grows gelatinous, if the digeſtion be performed in an open veſſel. If the digeſtion be performed in a long-necked or cloſe veſſel, it does not become gelatinous, but will afterwards become ſo if expoſed to the air. In the dry way, when one part of iron filings is diſtilled with four of acid of arſenic, the maſs makes a great efferveſcence towards the end; and, when it becomes dry, it takes fire upon increaſing the heat; arſenic and regulus of arſenic being ſublimed, and a black friable reſiduum being left at the bottom, which contains but little acid of arſenic. In this proceſs it appears, that the iron, which is a metal very much expoſed to combuſtion or calcination, ſuddenly deprives the arſenical acid of its vital air, and reduces it to the ſtate of calx and regulus; at the ſame time that, according to the ancient hypotheſis, phlogiſton paſſes from the metal to the acid. Little effect is produced upon lead by digeſtion with the arſenical acid; but the combination takes place by fuſion in the dry way, which affords a ſemi-opake glaſs. When this is boiled in diſtilled water, the lead falls down in the form of a white powder, containing arſenical acid, but which does not afford arſenic by heat, unleſs charcoal be added. Tin, digeſted with arſenical acid, grows black at firſt; afterwards becomes covered with a white powder, and at laſt the whole maſs becomes gelatinous. In the dry way, one part of tin filings with two of the acid, heated in a retort, took fire when ignited; and the calx and regulus of arſenic immediately ſublimed, leaving a limpid ſolution of tin, which, when cooled, was of a milky colour: this, when diſſolved in diſtilled water, depoſited a white calx, which contained very little acid of arſenic.

Zinc is the only metallic ſubſtance which efferveſces when digeſted with the arſenical acid. The zinc grows black, and the tranſparency of the acid is deſtroyed by a quantity of black powder, which, on examination, by burning on a red-hot iron, proves to be regulus of arſenic. This precipitated regulus ſoon defends the zinc from further ſolution. The air which eſcapes during the efferveſcence is inflammable, holding regulus of arſenic in ſolution, which it depoſits on burning. Either of the chemical theories will ſerve to explain theſe effects, for the zinc is calcined by receiving the vital air of the acid, while it is ſuppoſed to give out phlogiſton enough to reduce the acid baſis to a regulus, and to afford the inflammable air which eſcapes: or, in the other theory, it will be ſaid, that the zinc, having a ſtrong tendency to combine with vital air, and become calcined, cannot decompoſe water at a moderate temperature, unleſs an acid be preſent, to remove the coating of a calx by ſolution as faſt as it is formed, which mere water cannot do. This, therefore, is the firſt conſequence of the mutual action of water, zinc, and the acid; namely, vital air quits the water to unite with the zinc, and inflammable air flies off at the ſame time that the acid combines with the calx of zinc. But of the two metallic baſes, which are here combined by the intermedium of vital air, the zinc has a ſtrong tendency to calcination, and the arſenic to become revived: it appears, therefore, from the facts, that the zinc, attracting the vital air more ſtrongly, becomes ſtill more calcined, and conſequently leſs ſoluble; while the arſenic is reduced by the loſs of its vital air. Whence it muſt follow, that the metallic zinc which remains, being enveloped with calx of zinc and metallic arſenic, can no longer be acted on by the acid and water, which ſtill continue undecompoſed. On this, and ſimilar occaſions, it cannot, however, be too often repeated to the chemical ſtudent, that

that theories ought to be cautiouſly followed, as of uſe in the arrangement of facts, and in directing the path to future inveſtigations; that diſcriminating phænomena ought to be earneſtly ſought after, becauſe of infinitely more value than the moſt ingenious ſpeculations; and that an attachment to ſyſtem, though it frequently gives life and energy to the exertions of genius, is in general a certain ſource of prejudices, which diſable the enquirer from purſuing the ſearch after truth, and fix his mind upon words inſtead of things.

In the dry way, when one part of the filings of zinc was mixed with two of the arſenical acid, and diſtilled, the maſs took fire, with a very bright inflammation, as ſoon as the retort became red hot: the veſſel was burſt by the exploſion; and in its neck were found regulus of arſenic, and flowers of zinc. This effect may be explained from the ſame conſiderations as were applied to the combuſtion, which takes place in like circumſtances with iron.

Biſmuth is acted upon by the arſenical acid, in digeſtion. Water precipitates a powder from the ſolution, which conſiſts of acid of arſenic combined with calx of biſmuth. In the dry way, biſmuth is calcined by this acid, but not diſſolved, a little arſenic being ſublimed; and if water be added to the cooled maſs, the acid is taken up, but the calx remains. Regulus of antimony is affected nearly in the ſame manner as biſmuth, in the humid way; but, in the dry way, an inflammation takes place at the time of fuſion. By digeſtion with cobalt, the acid of arſenic aſſumed a roſe-colour; but much of the cobalt remained undiſſolved. The whole maſs being diſtilled to dryneſs, and fuſed, afforded glaſs of a violet colour and ſemi-tranſparent. Nickel communicates a green colour to this acid by digeſtion; a quantity of green powder, mixed with arſenic, being precipitated: the arſenic may be ſeparated by a gentle heat. In the dry way, the acid combines with nickel, and forms a yellow maſs with grey ſtreaks upon it, reſembling a vegetation. By boiling in water, the acid is taken up, and a yellow powder left behind, conſiſting of a combination of nickel and arſenic, moſt probably in the acid ſtate: the arſenic is reduced with charcoal, but the nickel is not. Calx of manganeſe is ſcarcely acted upon by acid of arſenic; but, when the manganeſe is partly or entirely reduced, it is diſſolved in the humid way, and affords cryſtals as ſoon as the acid is nearly ſaturated. The regulus of arſenic, digeſted with the arſenical acid, becomes covered with a white powder of arſenical calx. When one part of the regulus was mixed with two parts of the dry acid, and expoſed to diſtillation, the regulus was ſublimed before the heat was ſufficiently great to fuſe the acid, and conſequently no mutual action took place; but when the acid was firſt fuſed, and the regulus added ſucceſſively in ſmall lumps, inflammation took place, and calx of arſenic was ſublimed.

ACID OF BENZOIN. This acid, which is commonly known by the name of flowers of benzoin, or benjamin, is obtained by ſublimation from that reſinous ſubſtance. The operation is eaſily made, and affords a very elegant and pleaſing example of this chemical proceſs. For this purpoſe a thin ſtratum of powdered benzoin is ſpread over the bottom of a glazed earthen pot, to which a tall conical paper covering is fitted: a gentle heat is then to be applied to the bottom of the pot, which fuſes the benzoin, and fills the apartment with a fragrant ſmell, ariſing from a portion of eſſential oil and acid of benzoin which are diſſipated into the air; at the ſame time the acid itſelf riſes very ſuddenly in the paper head, which may be occaſionally inſpected at the top, though with ſome little care, becauſe the fumes will excite coughing. This ſaline ſublimate is condenſed in the form of long needles, or ſtrait filaments of a white colour, croſſing each other in all directions.

tions. When the ſalt ceaſes to riſe, the cover may be changed, a new one applied, and the heat raiſed: more flowers of a yellowiſh colour will then riſe, which require a ſecond ſublimation to deprive them of the empyreumatic oil they contain.

The ſublimation of the flowers of benzoin may be conveniently performed by ſubſtituting an inverted earthen pan inſtead of the paper cone. In this caſe the two pans ſhould be made to fit, by grinding on a ſtone with ſand, and they muſt be luted together with paper dipped in paſte. This method ſeems preferable to the other, where the preſence of the operator is required elſewhere. The heat applied muſt be very gentle, and the veſſels ought not to be ſeparated till they have become cool.

The quantity of flowers or acid obtained in theſe methods differs according to the management, and probably alſo from difference of purity, and in other reſpects of the reſin itſelf. It uſually amounts to no more than about one eighth part of the whole weight. The whole acid of benzoin is obtained with greater certainty in the humid proceſs of Scheele: this conſiſts in boiling the powdered reſin with lime-water, and afterwards ſeparating the lime by the addition of marine acid. Twelve ounces of water are to be poured upon four ounces of ſlaked lime; and, after the ebullition is over, eight pounds, or ninety-ſix ounces, more of water are to be added: a pound of finely-powdered benzoin being then put into a tin veſſel, ſix ounces of the lime-water are to be added, and mixed well with the powder; and afterwards the whole of the lime-water in the ſame gradual manner, becauſe the benzoin would coagulate into a maſs, if the whole were added at once. This mixture muſt be gently boiled for half an hour with conſtant agitation, and afterwards ſuffered to cool and ſubſide during an hour. The ſupernatant liquor muſt be decanted, and the reſiduum boiled with eight pounds more of lime-water; after which the ſame proceſs is to be once more repeated: the remaining powder muſt be edulcorated on the filter by affuſions of hot water. Laſtly, all the decoctions, being mixed together, muſt be evaporated to two pounds, and ſtrained into a glaſs veſſel.

This fluid conſiſts of the acid of benzoin combined with lime. After it is become cold, a quantity of marine acid muſt be added, with conſtant ſtirring, until the fluid taſtes a little ſouriſh. During this time the laſt-mentioned acid unites with the lime, and forms a ſoluble ſalt, which remains ſuſpended, while the leſs ſoluble acid of benzoin, being diſengaged, falls to the bottom in powder. By repeated affuſions of cold water upon the filter, it may be deprived of the marine ſalt and acid with which it may be mixed. If it be required to have a ſhining appearance, it may be diſſolved in a ſmall quantity of boiling water, from which it will ſeparate in ſilky filaments by cooling.

The acid of benzoin is ſo inflammable that it burns with a clear yellow flame without the aſſiſtance of a wick. The ſublimed flowers in their pureſt ſtate, as white as ordinary writing-paper, were fuſed into a clear tranſparent yellowiſh fluid, at the two hundred and thirtieth degree of Fahrenheit's thermometer, and at the ſame time began to riſe in ſublimation. It is probable that a heat ſomewhat greater than this may be required to ſeparate it from the reſin. It is ſtrongly diſpoſed to take the cryſtalline form in cooling. The concentrated acids of vitriol and of nitre diſſolve this concrete acid, and it is again ſeparated, without alteration, by adding water. Other acids diſſolve it by the aſſiſtance of heat, from which it ſeparates by cooling, unchanged. It is plentifully ſoluble in ardent ſpirit, from which it may likewiſe be ſeparated by diluting the ſpirit with water. It readily diſſolves in oils, and in melted tallow. If it be added in a ſmall proportion to this laſt fluid, part

of

of the tallow congeals before the reſt, in the form of white opake clouds. If the quantity of acid be more conſiderable, it ſeparates in part by cooling, in the form of needles or feathers. It did not communicate any conſiderable degree of hardneſs to the tallow, which was the object of this experiment. When the tallow was heated nearly to ebullition, it emitted fumes which affected the reſpiration, like thoſe of the acid of benzoin, but did not poſſeſs the peculiar and agreeable ſmell of that ſubſtance. A ſtratum of this tallow, about $\frac{1}{20}$ of an inch thick, was fuſed upon a plate of braſs, together with other fat ſubſtances, with a view to determine its relative diſpoſition to acquire and retain the ſolid ſtate. After it had cooled it was left upon the plate, and in the courſe of ſome weeks it gradually became tinged throughout of a blueiſh green colour. If this circumſtance be not ſuppoſed to have ariſen from a ſolution of the copper during the fuſion, it ſeems a remarkable inſtance of the mutual action of two bodies in the ſolid ſtate, contrary to that axiom of chemiſtry which affirms, that bodies do not act on each other, unleſs one or more of them be in the fluid ſtate.

This acid reddens litmus, but ſcarcely affects ſyrup of violets: it forms neutral ſalts with the alkalis, which are very ſoluble in water, and decompoſable by the mineral acids. With the vegetable alkali it forms a cryſtallizable deliqueſcent ſalt: with mineral alkali it affords efflureſcent cryſtals, and with the volatile alkali it forms a deliqueſcent ſalt, not eaſily brought to cryſtallize. Theſe ſalts are ſoluble in oils.

This acid forms a cryſtallizable ſalt with calcareous earth, which is not eaſily ſoluble in water, and has a ſweetiſh taſte without any pungency. With magneſia it forms ſmall feathery cryſtals, of a ſharp bitter taſte, and eaſily ſoluble in water; and with alum it forms an aſtringent ſalt.

The ſolubility of the acid of benzoin in nitrous and other acids, and its ſubſequent ſeparation, indicate that its principles are not eaſily ſeparable from each other. Attempts have been made to decompoſe it by repeated abſtractions of nitrous acid: the nitrous acid riſes firſt, ſcarcely altered, except towards the end, when it becomes fuming, and the acid of benzoin is afterwards ſublimed with little alteration. By repeating the proceſs, however, the acid of benzoin is ſaid to become more fixed, and at length to afford a few drops of an acid, reſembling the acid of ſugar in its properties.

This acid has been obtained in ſmall quantities from balſam of Peru, from ſtorax, and from the ſaponaceous extract of urine, which laſt ſubſtance afforded it by repeated abſtraction of the nitrous acid.

ACID OF BORAX, *or* SEDATIVE SALT. This acid has been found uncombined in the waters in certain lakes in Tuſcany and elſewhere; but it is moſt abundantly obtained from borax, which is a ſalt conſiſting of this acid united with mineral alkali. (See BORAX). This combination is not deſtroyed by expoſing the ſalt to a moderate degree of heat. The addition of ſome ſtronger acid is neceſſary to combine with the alkali. If martial vitriol be mixed with borax, and both be diſſolved in water, and evaporated till a pellicle appears, the liquor may then be put into a ſmall glaſs alembic: upon the application of heat the water firſt ariſes, and afterwards the ſedative ſalt, or acid of borax. In this proceſs the vitriolic acid of the martial vitriol quits its iron to unite with the alkali of the borax, at the ſame time that the acid of the borax in all probability combines with the iron: this laſt combination, however, is deſtroyed by the heat, and the acid of borax ſublimes alone. Mere vitriolic acid, or any other acid whoſe affinity with the alkali at the

temperature of ſublimation is ſtronger than that of the acid of borax, might be uſed with equal advantage in this decompoſition.

The acid of borax is moſt commonly, however, obtained in the humid way: for this purpoſe the vitriolic acid may be added to a ſaturated ſolution of borax in boiling water, in ſuch a proportion as that there may be a perceptible exceſs of acid; and the ſedative ſalt will be diſengaged in white ſcales as the water cools. Theſe muſt be rinſed in a ſmall quantity of very cold water.

The acid of borax requires about fifty times its weight of cold water for its ſolution, but much leſs when the water is boiling. In a moderate heat this concrete acid melts with leſs intumeſcence than borax itſelf, and runs into a clear glaſs, which is not volatile unleſs water be preſent. This glaſs does not differ from the original acid, except in having loſt its water of cryſtallization. If it be again diſſolved in water, it may be cryſtallized or ſublimed as before. It is ſoluble in ſpirit of wine, and communicates a green colour to the flame of that inflammable fluid: oils likewiſe diſſolve it by the aſſiſtance of heat. In the dry way it diſſolves earths, more particularly the ſiliceous earth.

The acid of borax retains its form in the air, but is ſomewhat diſpoſed to attract moiſture: it affords no precipitate upon the addition of Pruſſian alkali to its ſolution.

With vegetable alkali it forms a borax ſimilar to that of commerce: with mineral alkali it forms common borax, provided the alkali be in exceſs; and with volatile alkali it forms a cryſtallizable ſalt. Magneſia forms a compound with it which is decompoſable by all other acids, and by ſpirit of ſalt. Calcareous earth forms a ſalt of difficult ſolution. Argillaceous earth, in the humid way, forms a ſubſtance of difficult ſolution; and, by fuſion, in the dry way, with half its weight of ſedative ſalt, it affords a hard maſs reſembling pumice-ſtone, part of which is ſoluble in water. The phænomena with ſiliceous earth are nearly the ſame in a crucible; but the fuſion may be more completely effected by the blow-pipe. The action of the acid of borax upon gold is ſcarcely perceptible, either in the wet or dry way. It does not act at all upon platina, nor precipitate it from aqua regia. No direct action takes place between this ſalt and mercury, but it precipitates that metal from its ſolution in nitrous acid. A ſlight action takes place between this acid and copper in the direct way, and the ſolution of borax precipitates all the ſolutions of copper in acids. Lead is ſcarcely, if at all, acted on by ſedative ſalt, but it is thrown down in combination with it from the vitriolic, nitrous, marine, or acetous acids. One part of ſedative ſalt is ſaid to form, by fuſion with two parts its weight of minium, a fine, clear, hard, and inſoluble glaſs, of a greeniſh yellow colour. This acid has very little effect upon tin, with which, however, it may be brought to combine by long trituration and digeſtion with water. The ſlag formed by melting equal parts of ſedative ſalt and tin filings, afforded the ſame ſalt by ſolution in water. Iron is ſparingly ſoluble in acid of borax, and affords yellow cryſtals. A ſimilar ſolution may alſo be produced by fuſion and lixiviation. Regulus of antimony is not directly attacked, but its ſolution in aqua regia is precipitated by borax. Biſmuth, likewiſe, is not acted on, but is precipitated by borax from its ſolution in a mixture of vitriolic and marine acid. A ſlight action between this ſalt and zinc is produced by digeſtion, and the fluid by evaporation affords a ſaline maſs. The flowers of zinc melt with ſedative ſalt into a light green inſoluble ſlag. Calx of arſenic unites with this ſalt either in the humid or dry way, and forms a ſoluble and cryſtallizable compound. Regulus

of cobalt, and alſo nickel, are not directly acted on, but they are precipitated by it from their reſpective ſolutions.

ACID OF CITRONS, *or* LEMONS. The juice of lemons, or limes, has all the characters of an acid of conſiderable ſtrength: on account of the mucilaginous matter with which it is mixed in its firſt ſtate, it is very ſoon altered by ſpontaneous decompoſition. Various methods have been contrived to prevent this effect from taking place, in order that this wholeſome and agreeable acid might be preſerved for uſe in long voyages, or other domeſtic occaſions. The juice may be kept in bottles under a thin ſtratum of oil, which indeed prevents, or greatly retards its total decompoſition; though the original freſh taſte ſoon gives place to one which is much leſs grateful. In the Eaſt Indies it is evaporated to the conſiſtence of a thick extract. If this operation be carefully performed by a very gentle heat, it is found to be very effectual. When the juice is thus heated the mucilage thickens, and ſeparates in the form of flocks, part of which ſubſides, and part riſes to the ſurface: theſe muſt be taken out. The vapours which ariſe are not acid. If the evaporation be not carried ſo far as to deprive the liquid of its fluidity, it may be long preſerved in well cloſed bottles; in which, after ſome weeks ſtanding, a farther portion of mucilage is ſeparated, without any perceptible change in the acid.

Of all the methods of preſerving lemon-juice, that of concentrating it by froſt appears to be the beſt, though in the warmer climates it cannot conveniently be practiſed. Lemon-juice, expoſed to the air, in a temperature of between 50° and 60°, depoſits in a few hours a white ſemi-tranſparent mucilaginous matter, which leaves the fluid, after decantation and filtration, much leſs alterable than before. This mucilage is not of a gummy nature, but reſembles the gluten of wheat in its properties: it is not ſoluble in water when dried. More mucilage is ſeparated from lemon-juice by ſtanding in cloſed veſſels. If this depurated lemon-juice be expoſed to a degree of cold of about ſeven or eight degrees below the freezing point, the aqueous part will freeze, and the ice may be taken away as it forms; and if the proceſs be continued until the ice begins to exhibit ſigns of acidity, the remaining acid will be found to be reduced to about one eighth of its original quantity, at the ſame time that its acidity will be eight times as intenſe, as is proved by its requiring eight times the quantity of alkali to ſaturate an equal portion of it. This concentrated acid may be kept for uſe, or, if preferred, it may be made into a dry lemonade, by adding ſix times its weight of fine loaf ſugar in powder.

The above proceſſes may be uſed when the acid of lemons is wanted for domeſtic purpoſes, becauſe they leave it in poſſeſſion of the oils, or other principles, on which its flavour peculiarly depends; but in chemical reſearches, where the acid itſelf is required to be had in the utmoſt purity, a more elaborate proceſs muſt be uſed. Boiling lemon-juice is to be ſaturated with powdered chalk, whoſe weight is to be noted. The neutral ſaline compound is ſcarcely more ſoluble in water than ſelenite; it therefore falls to the bottom, while the mucilage remains ſuſpended in the watery fluid, which muſt be decanted off: the remaining precipitate muſt then be waſhed with warm water until it comes off clear. To the powder thus edulcorated, a quantity of vitriolic acid, ſufficient to ſaturate the chalk, and diluted with ten parts of water, muſt be added, and the mixture boiled a few minutes. The vitriolic acid combines with the lime, and forms ſelenite, which remains behind when the cold liquor is filtered, while the diſengaged acid of lemons remains diſſolved in the fluid. This laſt muſt be evaporated to the conſiſtence of a thin ſyrup, and vitriolic acid muſt be then added in ſmall portions, to precipitate the

lime, if any ſhould ſtill remain in combination with acid of lemons. When no more precipitate is afforded by the addition of vitriolic acid, a farther evaporation ſeparates the pure acid of lemons in cryſtals. It is neceſſary that the vitriolic acid laſt added ſhould be rather in exceſs, becauſe the preſence of a ſmall quantity of lime will prevent the cryſtallization. This exceſs will be found in the mother water.

The crude acid of lemons forms cryſtallizable ſalts with the mineral and the volatile alkalis; but its combination with the vegetable alkali does not cryſtallize. The pure acid affords uncryſtallizable and deliqueſcent ſalts with the fixed alkalis, and with volatile alkali a ſalt which yields its alkali in diſtillation. With calcareous, argillaceous, and ponderous earths, it forms ſalts of difficult ſolubility; but with magneſia a very ſoluble ſaline maſs reſembling gum. Its action on metallic bodies is not conſiderable, though it diſſolves iron and zinc, and during the ſolution affords inflammable air.

By repeated abſtraction of the nitrous acid from the acid of lemons it becomes converted into acid of ſugar. In this proceſs, as well as in others of the ſame nature, it is neceſſary that the quantity of nitrous acid ſhould not be too conſiderable, leſt its action ſhould convert the acid of ſugar into vinegar and fixed air. Two hundred grains of nitrous acid being abſtracted from ſixty grains of the acid of citrons, afforded thirty grains of acid of ſugar.

ACID OF FAT. The fat of animals is a ſubſtance nearly of the ſame nature as thoſe oils called fat oils in the vegetable kingdom: it affords an acid by diſtillation, which may be rendered purer by rectifying. Saturation with a fixed alkali, and ſubſequent diſtillation with vitriolic acid, render it ſtill purer, though contaminated with ſulphureous acid, unleſs the neutral ſalt has been previouſly kept in fuſion until all its oily particles are deſtroyed. If this acid be ſuppoſed to contain any portion of the vitriolic, it may again be rectified from ſome of the neutral ſalt.

The acid of fat may be obtained alſo from the ſolution of ſoap, formed with pure vegetable alkali and tallow: for this purpoſe the ſoap is to be boiled with water to the conſiſtence of a jelly. The tallow riſes to the top upon the addition of alum: the ſaline ſubſtance remaining in the water then conſiſts of vitriolated tartar, alum without the uſual quantity of acid, and a combination of the acid of fat with the vegetable alkali. By the addition of vitriolic acid to this ſaline maſs, the acid of fat may be obtained by diſtillation. But the moſt elegant method of obtaining this acid conſiſts in mixing a quantity of melted ſuet with quicklime, ſuffering the mixture to cool, and afterwards boiling it with a large quantity of water. After filtration and evaporation the calcareous ſalt, formed by the combination of the acid of fat with the earth, is obtained of a brown colour. A ſlight calcination renders it purer by the deſtruction of a portion of inflammable matter; and by ſolution, filtration, and the addition of a certain quantity of fixed air, to precipitate the ſuperfluous lime, a clear ſolution of the acid of fat, neutralized with calcareous earth, is obtained. Evaporation of the fluid affords the pure white ſalt; and this, when diſtilled, with the addition of vitriolic acid, affords the acid of fat, which comes over into the receiver, while the lime and vitriolic acid remain in the retort in the form of ſelenite.

The acid of fat is liquid, fuming, and of a penetrating odour; decompoſable with heat, which turns it yellow, and extricates or produces fixed air. Blue colours are ſtrongly reddened by it: water diſſolves it in all proportions. With lime, and alſo with the fixed alkalis, it forms cryſtallizable ſalts, which are not decompoſed in a moderate

moderate heat. With magneſia it forms an uncryſtallizable ſaline maſs, which may be reduced to a gummy conſiſtence. With clay, or pure argillaceous earth, it unites with difficulty, forming an aſtringent uncryſtallizable maſs. Siliceous earth is thought to be corroded by this acid, probably from its action on glaſs, in which it may act on the alkali and not on the earth, for it has no action upon ſiliceous earth precipitated from liquor of flints. It acts on a number of the metals. Gold and platina are not acted on; but it diſſolves the precipitates, which are thrown down from their acid ſolutions, by the addition of fixed alkalis. The acid of fat is, however, rendered capable of diſſolving gold by abſtraction from manganeſe. A very ſmall portion of ſilver is diſſolved by the acid of fat; and it takes ſilver and mercury from their ſolutions in nitrous acid, forming combinations which fall to the bottom. Mercury is not directly acted upon, unleſs the acid be repeatedly abſtracted from it. This proceſs changes the mercury into ſilver-coloured plates, which are ſoluble in the acid that comes over, not decompoſable by common ſalt, but depoſiting their quickſilver upon copper.

The acid of fat affords a white precipitate, with a ſolution of corroſive ſublimate. This is conſidered as a characteriſtic mark for diſtinguiſhing the acid.

Copper is diſſolved by the aſſiſtance of heat in the acid of fat, with which it forms a deliqueſcent cryſtallizable maſs. Iron likewiſe affords deliqueſcent cryſtals. Lead is corroded by it, and a conſiderable quantity of minium is diſſolved. Filings of tin are corroded by the ſebaceous acid into a yellow powder, eſpecially by the aſſiſtance of heat, and at the ſame time emit a very fœtid ſmell. The liquor, notwithſtanding filtration, continues turbid, depoſits in time a yellow powder, and acquires a fine roſe-red colour. By adding water to the yellow powder obtained by the corroſion, a white deliqueſcent ſalt may be formed; and a ſimilar ſalt may be obtained by diſſolving a yellow powder, which is precipitated by this acid from a ſolution of tin in aqua regis.

Regulus of antimony is ſoluble in the acid of fat by the aſſiſtance of heat, and forms a ſalt in permanent cryſtals. Zinc is eaſily and plentifully diſſolved. Biſmuth is not diſſolved in its metallic ſtate, but it precipitates this metal from its ſolutions in nitrous acid, and re-diſſolves the precipitate of biſmuth made by adding fixed alkali to that ſolution. The regulus of cobalt, or of nickel, are not diſſolved by this acid, neither does it afford a precipitate from their ſolutions in nitrous acid, but it diſſolves their precipitates obtained by the addition of alkali. White arſenic is copiouſly diſſolved in a gentle heat, and affords ſmall cryſtals. Manganeſe is likewiſe plentifully taken up, and affords a clear ſolution.

The acid of fat produces an ether by diſtillation in the uſual method with ſpirit of wine: it expels the acid from nitre, common ſalt, foliated earth, and Glauber's ſalt, by diſtillation. The acid of the laſt-mentioned ſalt comes over in the ſulphureous ſtate. It likewiſe precipitates the acid of tartar from a ſolution of ſoluble tartar, or vegetable alkali ſaturated with tartareous acid.

The acid of fat has not yet been decompoſed. When nitrous acid is abſtracted from tallow, there is a production of acid of ſugar, and not the ſebaceous acid. Hence it has been concluded, that this acid is nearly of the ſame nature as the other acids obtained from organized ſubſtances.

ACID OF FLUOR, *or* FUSIBLE SPAR. The fuſible ſpar, which is generally diſtinguiſhed by the name of Derbyſhire ſpar, conſiſts of calcareous earth in combination with the acid at preſent under our conſideration. If the pure fluor, or ſpar, be placed in a retort of lead, with a receiver of the ſame metal adapted, and half its weight of vitriolic acid be then poured upon it, the acid of ſpar will be diſen-

diſengaged in the aerial form by the application of a moderate heat. This acid air readily combines with water; for which purpoſe it is neceſſary that the receiver ſhould previouſly be half filled with that fluid. When experiments are required to be made with the acid in the elaſtic ſtate it muſt be received over mercury.

The diſtinguiſhing and moſt remarkable property of this acid is its power of combining with and volatalizing ſiliceous earth, which remains ſuſpended with it in the permanently elaſtic form. The firſt experiments with fluor ſpar were made in glaſs veſſels, and were attended with the ſingular phænomenon of an earthy matter being depoſited at the inſtant that the acid air came in contact with the water in the recipient. Upon examination it was found to conſiſt of ſiliceous earth; and ſubſequent experiments proved that it was obtained by corroſion of the glaſs retort, and depoſited in conſequence of the acid poſſeſſing a leſs power of ſuſpending ſiliceous earth when combined with water, than when in the elaſtic ſtate.

The acid of fluor unites with argillaceous earth, and forms a neutral ſalt of a gelatinous adheſive conſiſtence. Calcareous earth re-produces the fuſible ſpar. With ponderous earth it affords a ſalt of very difficult ſolution, which effloreſces in the air: it readily combines with magneſia, and forms a ſalt ſcarcely ſoluble in water, unleſs the acid be in exceſs, in which caſe the ſalt may be obtained in ſlender cryſtals by evaporation. Theſe cryſtals are not decompoſed by the heat of diſtillation, and not ſoluble in water, though in ſome meaſure in ſpirit of wine. None of the acids decompoſe this ſalt. The fluor acid takes magneſia from every other acid.

Siliceous earth being diſſolved by Bergman in diluted acid of ſpar, afforded, in the courſe of two years ſtanding, tranſparent cryſtals reſembling quartz, but not ſo hard. This acid has been ſucceſsfully uſed to make etchings upon glaſs, in the ſame manner as nitrous acid has long ſince been applied to copper. Whether this art can ever be applied to the multiplying of copies muſt be determined by future reſearches.

The acid of fluor unites with fixed alkalis, and forms ſalts of a gelatinous conſiſtence, which do not cryſtallize, but take a foliated form by evaporation. The combination of this acid and volatile alkali depoſits a gelatinous ſediment, and affords cryſtals, which are partly decompoſed by ſublimation, and attract moiſture from the air.

Gold, in its metallic ſtate, is not diſſolved by the fluor acid; but its precipitate, obtained by adding an alkali to the ſolution in aqua regia, is ſoluble. The action of this acid on platina is not known. Silver reſiſts its ſolvent power; but the precipitate thrown down by an alkali is ſoluble in part, and part remains undiſſolved. It throws down a precipitate from the nitrous ſolution of ſilver. Calx of lead is ſoluble in this acid. A powdery combination of the acid and the metal falls down when the ſolution is evaporated. Iron is powerfully attacked by the ſparry acid, at the ſame time that inflammable air is extricated. The ſolution does not cryſtallize, but is converted into a hard maſs by evaporation. Copper is attacked by this acid in its metallic ſtate, but much more eaſily when calcined: the ſolution affords blue cryſtals. Crude mercury is not attacked, but the acid unites with the calx of that metal obtained by means of alkali. Part of this compound remains in ſolution, and part falls down in a powder, which melts before the blow-pipe into a yellow glaſs, moſt of which evaporates during the continuance of the heat, and leaves a ſmall vitreous globule behind. The ſolution of mercury in nitrous acid is precipitated into a ſimilar powder by the addition of the acid of fluor. Tin is not attacked, but its calx is diſſolved by the fluor acid. Antimony and its regulus are not acted on.

Biſmuth

Biſmuth is affected nearly in the ſame manner as lead, and zinc in this reſpect is ſimilar to iron. Regulus of cobalt is not diſſolved, but it affords a yellow gelatinous ſolution with the calx of cobalt, and green cryſtals with the calx of nickel. It unites with arſenic, affording ſmall cryſtals; and with manganeſe, by pouring a ſolution of the volatile alkaline ſalt of fluor acid into a ſolution of manganeſe in any of the mineral acids.

The natural diſpoſition to refer our ſcientific acquiſitions to thoſe before known, has, as uſual, induced ſeveral chemiſts to inſiſt that the fluor acid is nothing but a modification of ſome other acid, more eſpecially the acid of ſea ſalt. Every experiment, however, hitherto made, tends to refute that conjecture; and the acid of ſpar appears to be as juſtly entitled to a ſeparate claſs, in the preſent ſtate of our knowledge, as any acid we are acquainted with. No experiments have yet been made which tend to ſhew the component parts of this acid ſubſtance. It is therefore only in the way of conjecture, or general inference, that, like the vitriolic, the nitrous, and other acids, in which the art of chemiſtry has been more ſucceſsful, it is ſaid to conſiſt of a combuſtible baſe united with vital air, according to the uſual mode of combination, whether the theory of the philogiſtian philoſophers be admitted, or that of their opponents.

ACID OF GALLS, *or* THE ASTRINGENT PRINCIPLE. Many vegetable ſubſtances, ſuch as the huſks of nuts, the bark of the oak, the nutgall, and other bodies of the ſame nature, abound with a ſubſtance which has been diſtinguiſhed by the name of the aſtringent principle. The nutgall is moſt plentifully uſed in dying proceſſes, and the other purpoſes wherein the property of producing a black colour with ſolutions of iron is required; and as this matter reſembles acids in its properties, it has been called the acid of galls.

The acid of galls is obtained by macerating the nutgall in water. This infuſion reddens turnſole and blue paper. The acid is ſoluble in oils, ardent ſpirit, and ether. Acids diſſolve it without impairing its property of forming a black precipitate with the ſolutions of iron: the diſtilled products of nutgalls likewiſe poſſeſs the ſame property. It decompoſes metallic ſolutions, and combines with their calces. Gold and ſilver are precipitated by it in the metallic ſtate. It acts upon and diſſolves iron directly.

To obtain the acid of nutgalls in a cryſtallized form, one pound of the powder of galls muſt be added to ſix pounds of diſtilled water, and left to digeſt for a fortnight, at the temperature of between 70 and 80 degrees; after which the fluid muſt be filtered, and left to evaporate ſpontaneouſly in the open air, in a ſtone ware or glaſs veſſel. The fluid becomes mouldy, and covered with a thick glutinous pellicle; abundance of glutinous flocks fall down; and in the courſe of two or three months the ſides of the veſſel appear covered with ſmall yellowiſh cryſtals, which are likewiſe very abundant at the under ſurface of the pellicle which covers the liquor. The fluid muſt then be decanted; and ardent ſpirit being poured upon the mucilaginous depoſition, the cryſtals and the pellicle, diſſolves the ſalt by the aſſiſtance of heat, without touching the mucilage; and, by evaporation of this ſpirituous ſolution, the pure gallic acid is obtained in ſmall brilliant cryſtals, of a grey colour inclined to yellow.

This acid, on account of its long expoſure to the air, may conſiſt either of a principle exiſting in the galls, or of that principle converted into an acid. It has the following properties: it precipitates martial vitriol, and other ſalts of iron, of a beautiful black colour, and ſtrongly reddens the tincture of turnſole: when heated with contact of air, it ſwells up and burns, leaving a coal behind of difficult incineration:

neration: by diſtillation with a gentle heat, part of the acid comes over diſſolved in the water of cryſtallization: another portion ſublimes undecompoſed in the form of ſilky cryſtals; and a ſtrong heat ſeparates a few drops of oil, with fixed and inflammable air.

The acid of galls is ſoluble in twenty-four parts of cold water, or three of boiling water. It is much more ſoluble in ſpirit of wine; four parts of this being ſufficient at the common temperature, or one when boiling hot. With lime, magneſia, or ponderous earth, it forms ſalts which are ſoluble in water: it unites readily with the alkalis, and forms compounds which have not been much attended to. The action of the nitrous acid converts it into the acid of ſugar. This acid precipitates gold, ſilver, mercury, copper, iron, and biſmuth, from their ſolutions; but it does not affect thoſe of platina, zinc, tin, cobalt, and manganeſe.

ACID, MARINE, *or* THE ACID OF SEA SALT, known in commerce by the name of ſpirit of ſalt. As common ſalt conſiſts of this peculiar acid united with the mineral alkali, by ſo ſtrong an affinity that both ſubſtances may be driven up by heat, inſtead of any ſeparation taking place, the acid itſelf cannot be obtained alone, but by means of proceſſes, in which a third ſubſtance is preſented to combine with the alkali. Various methods were formerly uſed, in which the common ſalt was ground together with earthy ſubſtances, and then expoſed to diſtillation. Theſe methods have been diſcontinued in England ſince the vitriolic acid has been obtained at an eaſy rate from ſulphur. In the ancient method, common ſalt was previouſly decrepitated, then ground with dried clay, and kneaded or wrought with water to a moderately ſtiff conſiſtence, after which it was divided into balls of the ſize of a pigeon's egg: theſe balls being previouſly well dried, were put into a retort, ſo as to fill the veſſel two thirds full; diſtillation being then proceeded upon, a ſpirit of ſalt came over when the heat was raiſed to ignition. In this proceſs eight or ten parts of clay to one of ſalt are to be uſed. The retort muſt be of ſtone ware well coated, and the furnace muſt be of that kind called reverberatory.

It was formerly thought that the common ſalt was merely divided in this operation by the clay, and on that account more readily gave out its acid: but there can be little doubt that the effect is produced by the ſiliceous earth which abounds in large proportions in all natural clays, and detains the alkali of the ſalt by combining with it.

The extrication of marine acid from common ſalt, by means of vitriolic acid, is much the moſt elegant and effectual. The Engliſh manufacturers uſe iron ſtills for this diſtillation, with earthen heads: the philoſophical chemiſt will doubtleſs prefer glaſs. One part, by weight, of ſtrong vitriolic acid is to be added to three of decrepitated ſea ſalt, in a retort whoſe upper part is furniſhed with a tube or neck, through which the acid is to be poured upon the ſalt. The aperture of this tube muſt be cloſed with a ground ſtopper immediately after the pouring. The vitriolic acid immediately combines with the alkali, and expels the marine acid in the form of a peculiar air, which is rapidly abſorbed by water, but may be confined by mercury. As this combination and diſengagement take place without the application of heat, and the aerial fluid eſcapes very readily, it is neceſſary to arrange and lute the veſſels together before the vitriolic acid is added, and not to make any fire in the furnace until the diſengagement begins to ſlacken; at which time it muſt be very gradually raiſed. Before the modern improvements in chemiſtry were made, a great part of the acid eſcaped for want of water to combine with; but by the uſe of Woulfe's apparatus (See APPARATUS), the acid air is made to paſs through water, in which it is condenſed, and forms marine acid of double the weight of the

water, though the bulk of this fluid is increaſed one half only. The acid condenſed in the firſt receiver, which contains no water, is of a yellow colour, ariſing from the impurities of the ſalt.

Heat expels the marine acid air from marine acid, and leaves the water behind. The fumes of ſpirit of ſalt conſiſt of this air in the act of uniting with the watery vapours of the atmoſphere, which render it viſible. The air has nearly the ſame affinities as the acid itſelf in the fluid form. The electric exploſion diminiſhes it a little; but the remainder is almoſt totally ſoluble in water as before.

In the action of acids upon other bodies they may be conſidered to operate either as entire ſubſtances, or by virtue of the diſpoſition which their component parts may reſpectively have to combine with the ſubſtance acted on. One of the moſt general actions of acids is that which anſwers the ſame purpoſe as combuſtion, either by depriving bodies of phlogiſton, or communicating vital air to them, or both. The acids which are moſt effectual in this reſpect are the moſt eaſily reduced to their component parts. The marine acid in its ordinary ſtate has very little effect upon combuſtible bodies, and is not ſuſceptible of changes, by their mutual action, ſimilar to thoſe which the vitriolic and nitrous acids undergo in like circumſtances. Its action on oils and ardent ſpirits is not conſiderable.

The aeriform marine acid acts more ſtrongly in a variety of inſtances than that which is diluted with water in the fluid ſtate. When this acid air is in contact with ſpirit of wine, oil of olives, oil of turpentine, charcoal, phoſphorus, bees wax, or ſulphur, it produces inflammable air. The theory of this effect will be, either that it diſlodges phlogiſton from theſe inflammable ſubſtances, or elſe that it combines with them at the ſame time that a decompoſition of the water, which compoſes a large part of all aerial ſubſtances, enſues; the vital air of the water combining with the inflammable ſubſtance, and burning it, while the inflammable air, or other component parts of the ſame water, is ſet at liberty. In this, as in a great variety of inſtances, the doctrine of the compoſition and decompoſition of water comes to the aſſiſtance of the new theory; and if this poſition could once be overthrown, the preſent experiments, and others of the like nature, would afford the ſtrongeſt proof of the exiſtence of inflammable air, or a general principle of combuſtibility in inflammable ſubſtances, or at leaſt in the acids applied to them, ſince it muſt come from the one or the other.

Spirit of wine abſorbs the aerial marine acid as readily as water itſelf does, and is increaſed in bulk by that means. When this fluid is ſaturated, it diſſolves iron with great rapidity, but nevertheleſs continues inflammable. When this air is added to a conſiderable quantity of oil of olives, it is abſorbed very ſlowly, at the ſame time that the fluid turns almoſt black, becomes glutinous, leſs miſcible with water, and acquires a diſagreeable ſmell. By continuing upon the ſurface of the water it became white, and its offenſive ſmell went off in a few days. Oil of turpentine abſorbs this air very faſt, turning brown, and almoſt black. No inflammable air was formed till more of the acid air had been raiſed than the oil was able to abſorb: the ſame was the caſe with the oil of olives. Bees wax abſorbs the aeriform marine acid very ſlowly, and produces inflammable air. Charcoal abſorbs this acid air very faſt, rendering one fourth of it immiſcible with water, and weakly inflammable. A ſmall bit of phoſphorus ſmoked and gave light in the acid air, in the ſame manner as it would have done in common air equally confined. When water was admitted to this air, it abſorbed the whole, except one fifth, which was weakly inflammable. Sulphur abſorbs marine acid air ſlowly, and leaves an inflammable remainder, which burns with a blue flame. Ether abſorbs it very faſt, becoming firſt of a turbid white,

and then of a yellow and brown colour. This ſaturated fluid is very volatile and inflammable, and the combination affords inflammable air. Camphor is rendered fluid by imbibing this acid air, but recovers its former ſolid ſtate upon the addition of water. Some veſtiges are exhibited in this experiment, of a combination having taken place between a minute portion of the acid and the camphor, attended with a production of inflammable air.

Marine acid air extinguiſhes flame, and is much heavier than common air. The electric ſpark is viſible in marine acid air exactly as in common air: neither the ſpark nor the exploſion, in the hands of Dr. Prieſtley, produced any change in this air which might not have been aſcribed to ſome caſual circumſtance. In the experiment with the great Harlem machine, a diminution of about one eighteenth took place in the courſe of five minutes, after which the paſſage of the electricity was reſiſted: a ſhorter ſpark was then applied for twenty-five minutes, which did not produce any perceptible alteration, and the air was as readily abſorbed by water as if it had not been electrified.

The marine acid in commerce has a ſtraw colour: but this is owing to accidental impurity; for it does not obtain in the acid produced by the impregnation of water with the aeriform acid.

The marine acid, in combination with the vegetable alkali, forms a ſalt, called ſalt of Sylvius, or improperly regenerated ſea ſalt: it is of a bitter taſte, ſlightly deliqueſcent, and ſoluble in about three times its weight of water. This is ſometimes uſed in medicine.

With the mineral alkali it forms common ſea ſalt.

With the volatile alkali it forms common ſal ammoniac; which is a conſiſtent ſalt of a ſharp briny taſte, and ſo remarkably deficient in the uſual brittleneſs of this claſs of bodies, that it is not eaſily pulveriſed. It is ſoluble in between three and four times its weight of water, in a common temperature. By heat it ſublimes entire in cloſed veſſels.

The ſaline combination of lime with marine acid is ſometimes called marine ſelenite, and ſometimes fixed ammoniac, becauſe it forms the fixed reſidue after ſal ammoniac has been expoſed to diſtillation with lime. This ſalt may be obtained in the form of cryſtals, but it deliqueſces in the air. It is ſoluble in leſs than twice its weight of cold water. The combination of lime and marine acid which remains after diſtilling ſal ammoniac has uſually an over proportion of lime. If it be urged by a violent heat, it fuſes; and when cold, it has the property of emitting a phoſphoric light upon being ſtruck with any hard body. Hence it is called Homberg's phoſphorus, from the name of the firſt obſerver.

The argillaceous marine ſalt has a gelatinous conſiſtence, when diſſolved in a ſmall quantity of water. Its taſte is ſtyptic, and it affords cryſtals by ſpontaneous evaporation.

The combination of ponderous earth with marine acid forms a cryſtallizable ſalt of difficult ſolution. Its ſolution is of admirable uſe for detecting the preſence of the vitriolic acid in any fluid; becauſe this laſt acid combines with the earth, and forms an inſoluble precipitate of ponderous ſpar. It is more eſpecially uſeful for purifying the marine acid itſelf from the vitriolic acid which it often contains. The exact quantity of ſolution neceſſary to be added for this purpoſe, to any veſſel of marine acid, may be known by previous trials with ſmall portions of the acid.

Magneſian marine ſalt exiſts in all ſalt waters. It is ſoluble in leſs than its own weight of water; and cannot be obtained in the cryſtalline form, but by firſt evaporating its ſolution, and then ſuddenly expoſing it to a great degree of cold. It is the

cauſe of the bitterneſs of ſea water; and, like moſt of the other ſalts laſt deſcribed, it is applied to no uſeful purpoſe.

The marine acid acts directly upon tin, lead, copper, iron, zinc, biſmuth, antimony, manganeſe, arſenic; but does not affect gold, ſilver, platina, mercury, wolfram, nor cobalt.

When the ſtrongeſt marine acid is mixed with ſpirit of wine, there is no conſiderable heat excited, and ſcarcely any combination takes place; but the dephlogiſticated or aerated marine acid is capable of converting ardent ſpirit into an ether.

ACID, MARINE AERATED, *or* DEPHLOGISTICATED. If the marine acid be diſtilled from about one fourth of its weight of the black calx of manganeſe, a ſuffocating elaſtic fluid ariſes, which corrodes mercury, and is abſorbed by water. If the concentrated acid be uſed, the diſengagement takes place without heat; but if it be weaker, a gentle heat is neceſſary. This operation may conveniently be performed in the apparatus of veſſels fig. 2. The common marine acid which may riſe is condenſed in the firſt bottle, and the dephlogiſticated acid vapour unites to the water in the ſecond: the water, as it becomes ſaturated, aſſumes a greeniſh yellow colour. When the ſaturation is complete, the dephlogiſticated acid takes a concrete form, and deſcends to the bottom in yellowiſh flocks, provided the temperature of the water be only a few degrees above freezing. An increaſe of temperature, ſuch as may be produced by applying the hand to the veſſel, cauſes this concrete matter to aſſume the aerial form, and eſcape in bubbles to the ſurface. The taſte of the ſolution is auſtere, but does not reſemble that of acids. It combines with fixed alkalis without cauſing them to give out their fixed air, if they be in a mild ſtate. Heated with lime or fixed alkali, it emits vital air, and then forms the ſame ſaline combinations as the common marine acid would have done with them. It diſſolves all metals directly, without affording inflammable air as the marine acid does with ſome of them, and its ſaline combinations are, for the moſt part, the ſame as the common marine acid produces when made to combine with them. Of theſe, however, we ſhall have occaſion to treat more fully under the reſpective metals. It deſtroys vegetable colours, rendering them white, without firſt cauſing them to become red; and it bleaches wax.

When the aeriform dephlogiſticated marine acid is received in a ſolution of pure vegetable alkali, and the liquor evaporated, two kinds of ſalt are obtained. The one is the common ſalt of Sylvius, which ſeparates from the fluid as the evaporation goes on; and the other is a ſalt which, being more ſoluble in hot than cold water, affords cryſtals by cooling. Theſe are of a rhomboidal figure, and a ſilvery brilliancy; have an inſipid, cooling taſte reſembling nitre; do not deliqueſce in the air, and detonate with charcoal or with iron more ſtrongly than nitre itſelf. This ſalt has been made into gun-powder of great force by trituration with charcoal and ſulphur. By heat alone this ſalt gives out vital air, and the reſidue of the detonation with charcoal, is the ſalt of Sylvius, or vegetable alkali ſaturated with marine acid. From theſe circumſtances it is evident, that a portion of the alkali imbibes the dephlogiſticated marine acid, together with a portion of the vital air which was employed in dephlogiſticating or aerating the remainder of the marine acid; and that this alkali forms the detonating ſalt, while the acid which was deprived of the overplus of air, and by that means reduced to the common ſtate, forms the ſalt of Sylvius, which is in much the greateſt proportion in the ſolution.

When a mixture of one ounce and a half of manganeſe with five ounces of concentrated marine acid, and three of ardent ſpirit, is expoſed to diſtillation by a very gentle heat, there is ſcarcely any production of elaſtic vapours, but a quantity of ethereal liquor ſlightly acid. In this proceſs, the whole of the dephlogiſticated acid appears to have united with the ardent ſpirit, and formed an ether.

The dephlogiſticated marine acid, in the aeriform ſtate, acts ſomewhat more powerfully upon bodies than when combined with water.

Much light has been thrown upon a variety of chemical appearances by this capital diſcovery of Scheele, in which the marine acid is ſo conſiderably changed. Of theſe we ſhall have occaſion to ſpeak as they preſent themſelves; for which reaſon we ſhall confine our attention in the preſent article to ſuch obſervations as tend to elucidate the theory of this converſion.

In the ancient theory, metals, being ſuppoſed to conſiſt of a calx united with phlogiſton, are ſuppoſed to be diſſolved in acids, either merely, or at leaſt chiefly, by the medium of part of their phlogiſton, to which the acid is ſuppoſed to have an attraction. For acids, being produced by the combuſtion or dephlogiſtication of inflammable ſubſtances, poſſeſs more or leſs of a diſpoſition to reſume their combuſtible ſtate according to the nature and conditions of affinity under which phlogiſton is preſented to them. The marine acid, having a comparatively weak action upon metals and other combuſtible bodies, was of courſe, therefore, preſumed to contain naturally a larger portion of phlogiſton. The black manganeſe is a calx of that ſemi-metal, which has a ſtrong tendency to become reduced to the metallic ſtate, or, according to the ſame enunciation, to attract phlogiſton. This therefore is what it does when it comes in contact with the marine acid at a proper temperature: It dephlogiſticates the acid, whoſe properties become by that means changed, inſomuch that it is rendered eminently capable of acting on combuſtible bodies, which at the ſame time reſtore its original ſtate by again adding the phlogiſton before attracted by the manganeſe.

The facility and perſpicuity of this explanation will be readily ſeen, and it was for a time admitted without controverſy. It is probable, indeed, that the ſcience of chemiſtry might never have afforded a better, if leſs attention had been paid to the elaſtic products which are of ſo much importance in every operation, though the ſcience of their effects is ſo very modern. It is from the examination of theſe permanently elaſtic ſubſtances, that the phlogiſtians have found themſelves under the neceſſity of admitting other effective cauſes in the combuſtion of bodies, beſides the mere tranſition of their inflammable principle; and from this it is that their opponents have been induced to maintain, that theſe other effective cauſes are ſufficient to ſolve the phenomena without the aid of that principle. How far the matter of heat emerging from a latent ſtate by the change of capacity in bodies may interrupt the general reaſoning, cannot perhaps be determined, while we know ſo little of that ſubject as leaves even its ſeparate exiſtence a matter of controverſy. But the tranſitions of the reſpirable part of the atmoſphere, or vital air, in combuſtion being matter of fact, which conſequently demands admiſſion in our explanations, tends immediately to bring forward the queſtion, how far thoſe tranſitions afford an adequate reſult without ſuppoſing any other ſubſtance. On the ſubject before us, the antiphlogiſtian philoſophers take notice, that manganeſe contains vital air, as is proved by its emitting that fluid when heated; and as they ſtate the act of combuſtion to conſiſt in the combination of vital air with any other body, they conſider the marine acid in that ſtate which was called dephlogiſticated, to be the acid combined with a larger proportion of vital air than it poſſeſſes in its ordinary ſtate. Its ſtrong action on combuſtible bodies does not therefore, according to them, conſiſt in depriving them of phlogiſton, but in communicating that vital air which is neceſſary to burn or calcine them, and which, in their theory, forms the medium of the ſolution of metallic calces in the ſame manner as phlogiſton does in the former theory.

Whatever reaſons the cautious philoſopher may find to doubt the ſtability of either theory, it is evident that the facts may be generalized without them. The dephlogiſticated marine acid is obviouſly removed farther from the ſtate of a combuſtible body

body than the common marine acid; whence it acts on all combuſtible bodies more ſtrongly. It appears worthy of remark, however, that its acidity with reſpect to alkalis and earths is not increaſed by this treatment, but on the contrary ſeems, as far as can be collected from circumſtances, to be diminiſhed. If this fact were clearly eſtabliſhed, the marine acid would follow a contrary law to that of the vitriolic and nitrous acids, which retain alkalis more ſtrongly, the more perfectly they are dephlogiſticated, or the larger the quantity of vital air which enters into their compoſition. It muſt nevertheleſs be noticed, that the phlogiſticated nitrous and vitriolic acids require a larger quantity of alkali for their ſaturation than before, though they retain it leſs ſtrongly.

ACID OF MILK. When milk is expoſed for ſome hours in a ſtate of repoſe, a ſmall quantity of thick fluid riſes to the top, and is known by the name of cream. This contains the fat ſubſtance called butter, which may be ſeparated from it by agitation in the act of churning. The remainder afterwards becomes ſour, and undergoes coagulation, which ſeparates it into two parts—a ſolid curd, and a fluid called ſerum or whey. This ſour whey contains a peculiar acid, called the acid of milk, and likewiſe a portion of vinegar. The peculiar acid does not riſe in diſtillation, but may be ſeparated by evaporating the filtered whey to one eighth; and precipitating the phoſphoric ſalt by the addition of lime water, which fully ſaturates its acid: the fluid is then to be diluted with three times its weight of water, and the lime precipitated by ſaccharine acid; in which operation the exceſs of the laſt-mentioned acid may be guarded againſt by the teſt of a ſmall portion of lime water. This purified liquor muſt then be evaporated to the conſiſtence of honey; and the other foreign ſubſtances it may contain will be ſeparated by the addition of pure ardent ſpirit, which takes up the acid of milk only. The decanted ſolution being then diluted with water, and heated, the ardent ſpirit flies off, and leaves the acid of milk behind, diſſolved in the water.

This acid does not afford cryſtals; and, when evaporated to dryneſs, it deliqueſces again by expoſure to air. With mineral alkali it affords a ſalt poſſeſſing the ſame properties. With volatile alkali it produces a deliqueſcent ſalt, which yields much of its alkali by diſtillation before the acid is deſtroyed by heat. With lime, clay, and ponderous earth it forms deliqueſcent ſalts; but with magneſia it affords ſmall cryſtals, which at length deliqueſce. The acid of milk diſſolves iron and zinc, and produces inflammable air. Copper affords a dark blue ſolution, which does not cryſtallize. Lead is diſſolved after ſome days digeſtion, and affords veſtiges of vitriolic acid. Biſmuth, cobalt, antimony, tin, mercury, ſilver and gold, are not affected by this acid in a digeſtive or boiling heat. Deſtructive diſtillation decompoſes the acid of milk: water firſt comes over; then a weak acid reſembling the empyreumatic acid of tartar; afterwards ſome empyreumatic oil, with more of the ſame acid, and alſo fixed air, and the heavy inflammable air. A coal remains in the retort.

ACID OF MOLYBDENA. Molybdena is a ſubſtance which greatly reſembles plumbago or black lead; but its texture is ſcaly, and it is not eaſily pulveriſed, on account of a degree of flexibility which its laminæ poſſeſs. It may however be reduced to powder by grinding in a mortar with ſome vitriolated tartar; the hardneſs and angular figure of the particles of this ſalt tending greatly to facilitate the diviſion. The ſalt may afterwards be waſhed off by three or four affuſions and decantations of hot water.

None of the known acids have any effect upon molybdena, except thoſe of arſenic and of nitre. The molybdena is not attacked by the acid of arſenic till he water is evaporated. If then the heat be increaſed a little, arſenic riſes into the neck of the retort,

retort, and towards the end of the operation yellow arſenic or orpiment is ſublimed. Volatile ſulphureous acid goes over into the receiver.

The concentrated nitrous acid being poured upon powdered molybdena in the proportion of two parts of the former to one of the latter; the mixture was ſcarcely warmed in the retort, before the whole maſs paſſed over into the receiver with great heat. Scheele conſiders this mixture as in danger of taking fire when the quantity is large, and therefore uſes the diluted nitrous acid.

Six ounces of diluted nitrous acid were diſtilled from one ounce and a half of the powdered molybdena. No effect took place during the digeſtion; but as ſoon as the mixture began to boil, red vapours were extricated with great intumeſcence, ſo that it is neceſſary to uſe a large retort. The diſtillation was continued to dryneſs; after which the ſame quantity of nitrous acid was again poured on the reſiduum, and diſtilled off with the ſame appearances as before. This proceſs was again and again repeated until the fourth or fifth time; the reſidual powder becoming leſs and leſs in quantity, until at laſt it conſiſted of ſix drams and a half of white pulverulent matter reſembling chalk. This ſubſtance, by edulcoration with hot water, afforded ſome acid of vitriol and a ſmall quantity of iron. The white pulverulent matter is the acid of molybdena. It exhibits weak acid properties. Molybdena may likewiſe be converted into the acid ſtate by detonation in a red hot crucible with four times its weight of purified nitre. The reddiſh alkaline maſs which remains is to be diſſolved in water, and affords both vitriolated tartar and nitre by evaporation. The remaining lixivium appears to conſiſt of a combination of the acid of molybdena with a portion of the alkali. This acid falls down, upon the addition of diluted vitriolic acid; which however muſt be cautiouſly added, becauſe an exceſs will ſuſpend the precipitate; and if the ſolution be hot, no precipitate whatever enſues. The nitrous or marine acids may likewiſe be uſed in this proceſs, inſtead of the vitriolic. It is not eaſy to deprive this precipitate of the laſt portions of alkali.

The acid of molybdena requires about five hundred times its weight of water to diſſolve it; and the ſolution reddens lacmus, coagulates the ſolution of ſoap, and precipitates liver of ſulphur. The addition of vegetable alkali forms a ſalt which is much more ſoluble in water than the pure acid itſelf, and affords cryſtals by evaporation. This neutral ſalt does not riſe by the action of heat, like the pure acid itſelf. With volatile alkali it forms a neutral ſalt, which parts with its alkali in a gentle heat. The ſolution of the acid of molybdena expels fixed air from chalk or magneſia, and effervesces with earth of alum, forming ſalts of difficult ſolution with theſe earths. It precipitates ponderous earth from its nitrous or marine ſolutions, and forms a neutral compound very ſparingly ſoluble in cold water; but it does not precipitate the ſolution of other earths. It precipitates ſilver, mercury, and lead from the nitrous acid, and alſo lead from the marine acid. Theſe precipitates are reduced by the blow-pipe upon charcoal, at the ſame time that the acid is abſorbed. The other metals are not precipitated. The neutral alkaline ſalts of molybdena precipitate all metallic ſolutions. Gold, corroſive ſublimate, zinc and manganeſe are precipitated in the form of a white powder; iron and tin from their ſolution in marine acid of a brown colour; cobalt, of a roſe colour; copper, blue; and the ſolutions of alum and quick lime, white.

The concentrated vitriolic acid diſſolves a conſiderable quantity of the acid of molybdena, the ſolution becoming of a fine blue colour as it cools, at the ſame time that it thickens: the colour diſappears again on the application of heat, but returns again by cooling. A ſtrong heat expels the vitriolic acid. The nitrous acid has no effect on it; but the marine acid diſſolves it in conſiderable quantity, and leaves a dark blue reſiduum when diſtilled. With a ſtrong heat it expels a portion of vitriolic

acid

acid from vitriolated tartar. It alſo diſengages the acid from nitre and common ſalt by diſtillation. It has ſome action upon the filings of the metals in the moiſt way.

When molybdena is fuſed with a fixed alkali, it forms an hepatic compound, that affords ſulphur by precipitation; from which circumſtance the preſence of ſulphur in this mineral is aſcertained. The ſame fact is likewiſe aſcertained from the preſence of vitriolic acid in the analyſis of molybdena, when it is acidified by the abſtraction of nitrous acid. This truth is alſo aſcertained ſynthetically. When the acid of molybdena is heated with ſulphur in a retort, placed in ſuch a manner as that the ſublimed ſulphur may melt and run back again, a combination between theſe two ſubſtances is at length produced, and the ſuperfluous ſulphur flies off, being partly converted into volatile vitriolic acid. The reſidue is found to be, in every reſpect, the ſame as the native molybdena. The analyſis of molybdena by the nitrous acid, ſhewed that it conſiſts of ſulphur united to a peculiar acid, or acid baſis; and this ſynthetical production of molybdena proves the ſame thing.

ACID NITROUS, *or* THE SPIRIT OF NITRE OF COMMERCE. This acid is obtained by diſtillation with an intermedium, nearly in the ſame manner as in the manufacturing of the marine acid. In the proceſs for making that ſpirit of nitre, which is called aqua fortis, two parts of dry and powdered clay are well mixed with one part of nitre in a ſtone ware retort, to which a veſſel of the ſame form and kind is luted as a receiver. The diſtillation is effected by an heat gradually raiſed to ignition in a reverberatory furnace. The ſiliceous earth with which the clay abounds unites with the alkali of the nitre, and ſets its acid at liberty. Very good ſpirit of nitre may be made in this way; but the manufacturers ſeldom uſe any conſiderable degree of care, on account of the low price at which they ſell the product. The nitre they make uſe of in general contains common ſalt; from which circumſtance the aqua fortis is often vitiated by an admixture of marine acid.

Spirit of nitre is obtained either by the intermedium of martial vitriol, or of the vitriolic acid itſelf. In the firſt method the vitriol is deprived of its water of cryſtallization by heat, and then mixed with an equal weight of very pure nitre, both ſubſtances being previouſly pulverized. They are then poured into a good earthen ware retort through a paper funnel, which paſſes into the belly of the retort, and prevents any of the powder from adhering to its neck. The retort is placed in a reverberatory furnace upon an earthen diſh filled with ſand. A large glaſs balloon or receiver is to be fitted and luted to the retort with fat lute, round which is to be wrapped a cloth ſoaked in a thin paſte of the white of eggs, and ſlacked lime. It is neceſſary that the receiver ſhould have a ſmall hole in its upper part, for the elaſtic vapours to eſcape. The diſtillation muſt be commenced with a very ſlow fire. Red vapours are ſoon extricated, and the ſpirit of nitre paſſes over in drops. As ſoon as the retort is red hot, and the vapours ceaſe to come over, the fire muſt be ſlackened and ſuffered to go out; and when the veſſels are cooled, the receiver muſt be cautiouſly withdrawn, and its contents quickly poured through a glaſs funnel into a clean and dry glaſs bottle, which is to be immediately afterwards cloſed with a glaſs ſtopper. Great care muſt be taken to avoid the fumes which ariſe during the pouring of this acid. The beſt method of doing this, conſiſts in ſtanding in a current of air, ſo that the vapours may be blown from the operator. Other precautions are likewiſe neceſſary in the management of the heat, and the occaſional opening of the ſmall hole of the receiver. But theſe difficulties are in a great meaſure removed by the pneumatic apparatus of Woulfe. *See* APPARATUS.

The ſpirit of nitre obtained in this way is of the kind called phlogiſticated, and emits copious fumes, which aſſume a dark red colour when they mix with the air.

The method of diſtilling nitrous acid from nitre by the intermedium of vitriolic acid is much more eaſy, quick and convenient than the foregoing. It is performed by putting a quantity of very pure nitre into a ſtone ware or glaſs retort. Upon this one third part of highly concentrated vitriolic acid is to be poured through a glaſs funnel, the ſtem of which ought to be ſufficiently long to reach into the belly of the retort. The receiving apparatus muſt be adopted as in the foregoing operation, and the proceſs muſt be conducted with ſimilar precautions.

If it be ſuſpected that any portion of vitriolic acid may have paſſed over towards the end of the operation, the acid may be rectified by diſtillation from a portion of very pure nitre. The quantity of nitrous acid obtained in this way, is about five eighths of the weight of the nitre.

When nitrous acid is ſuſpected to be adulterated with marine acid, it is purified by the addition of ſmall portions of the nitrous ſolution of ſilver, which is to be added as long as any precipitate falls down. The precipitate conſiſts of the ſilver united with marine acid. It is advantageous in the firſt place to aſcertain the due quantity of metallic ſolution neceſſary to be added to a large quantity, by making experiments with ſmaller quantities of the two fluids.

The obvious characters of nitrous acid, are: 1. It is of a yellow or reddiſh colour, but may be rendered pellucid by a ſlight boiling in a retort, which expels a quantity of elaſtic fluid, known by the name of nitrous air. 2. It emits yellow fumes, which conſiſt of nitrous air in the act of uniting with the vital air of the atmoſphere. 3. Its greateſt ſpecific gravity is 1580 : 1000 compared with water, and it has a conſiderable degree of volatility. 4. When highly concentrated, it ſtrongly attracts the humidity of the atmoſphere. 5. It developes a conſiderable degree of heat when mixed with water, but when mixed with ice it produces intenſe cold. 6. A certain proportion of water converts its colour to a deep blue or green, while the vapours ſtill continue of their original yellowiſh red. 7. The action of light expels vital air from the pale nitrous acid, at the ſame time that the acid obtains a deeper or yellowiſh colour.

This acid in combination with calcareous earth forms a ſalt, whoſe cryſtals deliqueſce by expoſure to the air, and are ſoluble in twice their weight of cold, or their own weight of boiling water. With ponderous earth, it forms a ſalt of difficult ſolubility. With magneſia, it forms an acrid bitter ſalt, which is very ſoluble in water, and deliqueſcent in the air. With clay, it forms an auſtere ſalt of difficult ſolution. None of theſe have yet been applied to any uſe.

With the vegetable alkali this acid forms common nitre; a ſalt whoſe production, and the influence its uſes have had upon civil ſociety, render it an object worthy of the moſt particular attention. *See* NITRE *and* GUN-POWDER.

With the mineral alkali, it forms a ſalt, called quadrangular nitre, from the uſual form of its cryſtals. About three times its weight of water is required to hold it in ſolution in a mean temperature, and it is ſcarcely more ſoluble in hot water. Its properties reſemble thoſe of common nitre; but it is leſs fit for making gun-powder, becauſe it attracts the humidity of the air.

The nitrous acid in combination with the volatile alkali forms nitrous ammoniac, a ſalt which ſlightly attracts the humidity of the air, and is ſoluble in leſs than its own weight of water. If this ſalt be expoſed to heat in cloſed veſſels, it ſuddenly explodes; part of the acid and alkali are deſtroyed, and the aerial product is phlogiſticated air.

There is no part of chemical ſcience more eminently inſtructive, or more fruitful in its conſequences, than that which relates to the nitrous acid. In many inſtances, it is compoſed, and in others decompoſed, or reduced to its component parts; and it has been in a great meaſure, from the analogies afforded by the phenomena of this acid,

acid, that the general and very perſpicuous modern doctrine of the nature of acids has been derived.

It has long been well known, that the nitrous acid, inſtead of exiſting in conſiderable maſſes in the mineral kingdom, like the vitriolic and marine acids, is almoſt always produced by a concurrence of circumſtances, chiefly conſiſting in the expoſition of putrefying ſubſtances to the atmoſphere, together with a calcareous or other baſe to receive the acid. Upon theſe facts was founded the popular notion of nitrous particles exiſting in the air. Meſſrs. Thouvenels, in their memoir which gained a prize from the Academy of Paris, relate a variety of experiments in which the natural proceſs of the formation of nitre was imitated. They obſerve that calcareous earths, in the mild ſtate, are the fitteſt baſes for the reception or production of nitre; that magneſia and clay have very little effect, and alkalis none at all; that the preſence of atmoſpherical or vital air is neceſſary in this proceſs, but no length of expoſure of the calcareous baſes to vital air alone is ſufficient to produce nitre; that none of the permanently elaſtic fluids or airs afford nitrous acid, excepting air impregnated with putrid effluvia; and that this air was deprived of its virtue in this reſpect by waſhing in lime water, or in a cauſtic alkali. From theſe experiments, which were performed by expoſure of the ſubſtances reſpectively to each other during a long courſe of time in very large glaſs veſſels, it appears to be eſtabliſhed, that nitrous acid is produced by the union of two or more principles which are always found in atmoſpherical air, and in the exhalations from putrid ſubſtances. But it is to Mr. Cavendiſh that we are indebted for the capital diſcovery, that nitrous acid is produced when a mixture of phlogiſticated and of vital air is expoſed for a long time to the action of the electric ſpark.

This * experiment was performed by encloſing a mixture of two parts, by meaſure, of vital air, obtained without the uſe of nitrous acid, and one of phlogiſticated air, or, which is the ſame thing, five parts of vital and four of common air, in the upper part of a ſyphon in which it was confined by mercury. The legs of the ſyphon ſtood in two ſmall glaſs veſſels ſeparately inſulated, to one of which the electric ſparks were communicated, and paſſed off to the common ſtock through the other. A ſmall quantity of ſoap lees, or ſolution of cauſtic alkali, was admitted into the cavity which contained the air. This is a ſlow operation, and requires the quantity of air to be renewed very often, to ſupply the abſorption which takes place. The abſorbed matter is found to conſiſt of nitrous acid, as is plainly proved by the exiſtence of true nitre in the ſoap lees. When the electricity is ſtrong, no indication of the ſoap lees becoming ſaturated is afforded by any ceſſation in the diminution of the air; but the nitrous acid continues to be abſorbed, and enters into combination with ſome of the mercury. This admixture of mercurial nitre prevents the deflagration of paper dipped in the ſoap from being ſo vivid as it would otherwiſe have been. Mr. Cavendiſh apprehends that the quantity of acid produced, and conſequently the ſaturation of the ſoap lees depends only on the quantity of phlogiſticated air abſorbed, and that the effect of the greater or leſs quantity of dephlogiſticated air is only to make the nitre produced more or leſs phlogiſticated. In the experiment performed in the year 1787, the bulk of the phlogiſticated air was $12\frac{2}{10}$ that of the ſoap lees. In Mr. Cavendiſh's firſt experiment, it was $11\frac{9}{10}$, and in his laſt $10\frac{8}{10}$.

The reaſoning of philoſophers upon this leading fact has been as various as their reſpective notions concerning the compoſition of the two airs. Thoſe who believe that the fluid called phlogiſticated air does conſiſt of an elaſtic fluid containing a

* Conſult Mr. Cavendiſh's papers in the Philoſophical Tranſactions, vol. lxxv. and vol. lxxviii.

conſiderable portion of phlogiſton, have ſuppoſed that the vital or dephlogiſticated air, by the proceſs of combuſtion, deprived the phlogiſticated air of the principle of inflammability; ſo that the nitrous acid with them is the baſis of phlogiſticated air. Others, perhaps with equal probability, have ſuppoſed that the nitrous acid was produced by the union of vital air with a due proportion of the inflammable principle obtained from the phlogiſticated air: and laſtly, the chemiſts who reject phlogiſton altogether, and are deſirous of conſidering all bodies as ſimple until they are proved by experiment to be compounded, affirm that the two airs which diſappear in this experiment, have combined together, and, conſequently, that nitrous acid is a compound of vital air and phlogiſticated air. Whichſoever of theſe inferences be employed in the general explanation of the facts, it is evident, that a certain degree of conſiſtency will attend the explanation throughout, becauſe, generally ſpeaking, the inſertion of ſuppoſitions which, though not fully warranted by experiment, are not contradictory to the facts we are in poſſeſſion of, will not be productive of abſurdity, though it tends greatly to leſſen the ſimplicity of any explanation. In the reſt of this article we ſhall however, as the ſafeſt and leaſt intricate method of proceeding, conſider the nitrous acid as compoſed of vital and phlogiſticated air, without entering into the enquiry whether thoſe airs be ſimple or compound bodies, relative to the preſent ſtate of our knowledge.

Nitrous acid has been lately produced by the Rev. Iſaac Milner *, of Cambridge, in a leſs ſimple though very perſpicuous and elegant manner. He expoſed the volatile alkali in the aerial form, to vital air, at the inſtant of its extrication from manganeſe ignited in a gun-barrel. The manganeſe was uſed in rough powder, for when it is too finely powdered, the tube becomes choaked up. Cauſtic volatile alkali was contained in a retort affixed to the end of the gun-barrel, and this was made to emit alkaline air by boiling. At the other end of the gun-barrel was a tube which paſſed beneath a pneumatic apparatus. It muſt be imagined of courſe that the manganeſe occupied the middle of the gun-barrel, at which place the heat was applied to ignite it. The conſequence was, that nitrous air came out of the end of the gun-barrel at the time that the alkaline air was introduced at the other end: but this effect did not take place without the preſence of the alkaline air. Mr. Milner obſerves, that there is a cauſe of deception in the experiment, againſt which the operator ought to be on his guard, leſt he ſhould conclude that no nitrous air is formed, when in reality there is a conſiderable quantity. The volatile alkali, notwithſtanding every precaution, will frequently paſs over in great quantities undecompoſed. If the receivers are filled with water, a great part of this will indeed be preſently abſorbed; but ſtill ſome portions of it will mix with the nitrous air formed by the proceſs. Upon admitting the atmoſpherical air, the nitrous air is decompoſed, and the red nitrous fumes inſtantly combine with the volatile alkali. The receivers are preſently filled with white clouds of nitrous ammoniac; and in this manner a wrong concluſion may eaſily be drawn, from the want of the orange colour of the nitrous fumes. A conſiderable quantity of nitrous air may have been formed, and yet no orange colour appear, owing to this circumſtance; and therefore it is eaſy to underſtand how a ſmall quantity of nitrous air may be moſt effectually diſguiſed by the ſame cauſe.

This acute chemiſt, conſidering that there are many other ſubſtances beſides the calx of manganeſe which are known to afford dephlogiſticated air, was induced to make the experiment, whether they would not alſo afford nitrous air upon the application of volatile alkali. With red lead, his experiments did not ſucceed; but he

* Philoſophical Tranſactions, vol. lxxix, page 306.

finds

finds it difficult to perſuade himſelf that it would not anſwer with a more perfect apparatus than that uſed by himſelf. With calcined martial vitriol he had much better ſucceſs. The ſalt was calcined to whiteneſs, and put into a gun-barrel; and after ſeveral trials of forcing the volatile alkali through the hot tube, he procured ſome ounces of ſtrong nitrous air.

As calcined green vitriol affords vital air when urged by a ſtrong heat, he had no doubt, after this experiment, but that any ſubſtance poſſeſſing the ſame property might, by ſimilar treatment, be made to afford nitrous air. But in this ſuppoſition he found himſelf entirely miſtaken. The volatile alkali was applied to ſome calcined alum at the moment when it was yielding, in a ſtrong heat, plenty of dephlogiſticated air. The product was an aſtoniſhing quantity of inflammable air mixed with hepatic air and actual ſulphur. The reſiduum of the alum had a ſtrong hepatic ſmell, and contained particles of perfectly formed ſulphur.

Moſt of the experiments, if not all, were repeated in earthen tubes inſtead of gun-barrels, and with the ſame ſucceſs.

After premiſing a circumſtance of which we have not yet ſpoken, namely, that nitrous air ſpontaneouſly unites with vital air, and forms nitrous acid; from which and other facts it is ſeen that nitrous air conſiſts of the acid in an imperfect ſtate, for want of a due proportion of vital air; and conſequently that the production of nitrous air may be conſidered as a production of nitrous acid: we cannot do better than add the explanation or theory of the foregoing facts in the words of the author.

"1. Nitrous air and dephlogiſticated air, by mixture, produce nitrous acid; and nitrous acid, by mere heat, is converted into a mixture of phlogiſticated and dephlogiſticated airs.

"2. Nitrous air, by the methods already related, is changed into phlogiſticated air; and theſe methods ſeem to conſiſt in abſtracting from the nitrous air a quantity of dephlogiſticated air.

"3. When nitrous acid and nitre are produced in a natural way, the proceſs is not well underſtood; but the preſence of the atmoſphere is known to be neceſſary.

"4. Mr. Cavendiſh's experiment is deciſive on this point. The union of the two airs in queſtion is effected by means of the electrical ſpark, and nitrous acid is the product.

"In the next place we are to conſider, that volatile alkali contains phlogiſticated air; for,

"1. Volatile alkali, by mere heat, or by the electrical ſpark, is changed into a mixture of phlogiſticated and inflammable air; and,

"2. The reſiduum of volatile alkaline air, after the calces of the lead have been revived in it, is phlogiſticated air.

"Therefore, when volatile alkali, in the form of fume or air, is applied to red hot manganeſe, or calcined green vitriol (ſubſtances which are then yielding dephlogiſticated air), with theſe facts in view, it ſeems not difficult to conceive, that one of the ingredients of the alkali, viz. phlogiſticated air, ſhould combine with dephlogiſticated air, and form nitrous acid or nitrous air. If nitrous acid be formed, it will indeed, in that heat, as has been obſerved, be inſtantly decompoſed; but if the effect of the union be nitrous air, that will ſuſtain the heat without decompoſition. How it happens, that nitrous air ſhould be formed, and not nitrous acid, or what the reaſon is, that nitrous air can ſuſtain a red heat without decompoſition, when nitrous acid cannot, I am unable to ſay; and it is better to acknowledge our ignorance than advance groundleſs conjectures. So much, I think, may be pronounced

as certain, viz. that nitrous air contains leſs dephlogiſticated air than nitrous acid; becauſe it requires the addition of dephlogiſticated air to become nitrous acid.

"And laſtly, if I miſtake not, the experiment with the calcined alum proves, that, in order to produce nitrous air, it is not ſufficient merely to apply volatile alkaline air to a ſubſtance which is actually yielding dephlogiſticated air.

"Perhaps the preſence of another ſubſtance is required, which has a ſtrong attraction for phlogiſton. Perhaps, in the experiments with the calces of manganeſe and of iron, the inflammable principle of the volatile alkali combines with the calces of the metals, and the phlogiſticated air, the other component part, unites with the dephlogiſticated air; and if ſo, it ſeems not improbable to ſuppoſe, that when alum is made uſe of, the inflammable principle of the volatile alkali having little or no attraction for clay, the baſis of the alum ſhould combine with its acid, and form ſulphur. If this reaſoning be true, then it follows, that the vitriolic acid has a ſtronger affinity to the inflammable principle than it has to phlogiſticated air; and the proceſs with the green vitriol and manganeſe is to be explained by the operation of a double affinity: the inflammable principle of the volatile alkali joins with the calx of iron, the baſis of the vitriol, or with the manganeſe, and the phlogiſticated air with the dephlogiſticated air produced by the acid in the red heat.

"Thoſe who chooſe to reject the doctrine of phlogiſton muſt make the neceſſary alteration in theſe expreſſions: but the reaſoning will be much the ſame."

The experiments which ſhew the decompoſition of nitrous acid are not leſs inſtructive than thoſe which prove its compoſition. When pale nitrous acid is expoſed to the action of light, there is an emiſſion of vital air, and the colour of the acid becomes deeper than before.

This effect of light appears to take place upon the nitrous vapour in which the dephlogiſticated air is rendered permanently elaſtic, while the imperfect acid or nitrous air is abſorbed by the fluid. It ſhould ſeem therefore that the dephlogiſticated or vital air is more diſpoſed to aſſume the permanently elaſtic ſtate than the other component part, namely, the phlogiſticated air, which laſt appears obſtinately to retain a portion of the vital air, ſo as to preſerve the form of nitrous air.

Mere heat, applied to the acid by boiling it in glaſs tubes of a ſufficient capacity or length to admit of the operation being performed in perfect ſafety, effects the ſame thing. Vital air is emitted, and the acid becomes of a deeper colour, or phlogiſticated. In theſe facts *, however, there are circumſtances which appear to indicate that the proceſſes are not quite ſo ſimple as here ſtated. The dephlogiſticated air emitted is by no means perfectly pure; and when the upper part of the tube is previouſly filled with phlogiſticated or with inflammable air, the quantities of theſe are diminiſhed. Theſe circumſtances ſeem to indicate either a decompoſition of the water, or a greater degree of compoſition in the reſpective aerial ſubſtances, particularly the phlogiſticated air, than chemiſts have of late years been habituated to allow. In the uſual diſtillation of nitrous acid the ſame decompoſitions take place, according to the degree of heat, the quantity of vital or reſpirable air extricated being greater, and the acid of a deeper colour, the ſtronger the heat.

The decompoſition of nitrous acid by paſſing its vapour through an ignited earthen tube is much more effectual. Dephlogiſticated air and phlogiſticated acid vapour are very abundantly † produced. The phlogiſticated acid being again

* See Prieſtley in Phil. Tranſactions, vol. lxxix. † Ibid.

ſubjected to the ſame operation, did not afford any more vital air, but paſſed nearly unchanged, excepting that a ſmall portion was obtained towards the end, which probably aroſe from ſome nitrous acid which had eſcaped the action of the heat in the former proceſs. Nitrous air is not changed by tranſmiſſion through an ignited glaſs or earthen tube.

When the electric ſpark is repeatedly taken through nitrous air, in the ſame manner as in Mr. Cavendiſh's experiment for producing nitrous acid, a ſimilar effect takes place. Nitrous acid is produced, and a reſidue of about half the original bulk is left, which conſiſts of phlogiſticated air; a proof that nitrous air conſiſts of the acid not ſufficiently ſaturated with vital air, or, which is the ſame thing, containing a ſurplus of phlogiſticated air. The fact is worthy of the moſt attentive inveſtigation of philoſophers, that electricity ſhould produce an effect ſo oppoſite to that of heat. This laſt power tends to diſunite the principles of nitrous acid; whereas electricity renders their combination more intimate.

The nitrous acid is decompoſed by heating together with different earths and metallic calces. The decompoſition is, no doubt, greatly aſſiſted by the fixed nature of theſe ſubſtances, which detain the acid, and by that means cauſe it to undergo a greater heat than it would elſe have been ſubjected to. When common nitre is expoſed to a ſtrong heat, it melts, and becomes red hot, and the volatile product is found to conſiſt of fuming nitrous acid, a large quantity of vital air, and ſome phlogiſticated air, the alkali remaining behind ſomewhat altered by a portion of the earth of the retort, which it diſſolves. Various chemiſts differ in their accounts of the reſults of this experiment; which, indeed, may naturally be expected when we attend to the extreme difficulty of aſcertaining the weights of aerial products, as well as the fixed reſidues, and at the ſame time conſider that the quantity of nitrous acid decompoſed at this elevated temperature, muſt in all probability differ according to the greater or leſs degree of heat; in the ſame manner as happens in the operations at lower temperatures. From theſe circumſtances, it becomes a taſk of conſiderable difficulty to determine the intermediate ſteps of this operation.

The foregoing effects tend to explain what happens when nitrous acid is decompoſed, in conſequence of the ſuperior electrive attraction of its component parts to other ſubſtances. As the adheſion of theſe parts to each other in the full ſtate of ſaturation which forms nitrous acid, is by no means ſtrong; this acid acts upon almoſt every combuſtible ſubſtance, and produces effects in them, which are of the ſame nature as thoſe which take place when vital air is abſorbed in the act of combuſtion. In theſe operations with the nitrous acid, its vital air unites with the combuſtible body, while the remaining acid becomes fuming, and aſſumes the various colours which attend its phlogiſtication or defect of vital air, at the ſame time that it emits nitrous air with ebullition. The effects of the combination of vital air or combuſtion are, either calcination or acidification, according to the nature of the ſubſtances reſpectively; and the aerial fluid which flies off, being either nitrous air, dephlogiſticated nitrous air, or phlogiſticated air, it will be proper to ſpeak in this place of the two firſt. For the latter, *ſee* AIR PHLOGISTICATED. *See, likewiſe,* ACID.

Nitrous air is a tranſparent, permanently elaſtic fluid, which may be received over water, as that fluid does not imbibe more than $\frac{1}{10}$ of its bulk of the air. Nitrous air thus imbibed is not found to have ſuffered any change in its properties, if it be immediately expelled by heat. When the nitrous air is leſs in quantity than is ſufficient fully to ſaturate the water, the reſidue which is unabſorbed

ſorbed is found to be phlogiſticated air. The nitrous acid itſelf, when volatilized by heat, appears to be capable of retaining its elaſtic ſtate, but can ſcarcely be operated upon, becauſe of its action upon, or diſpoſition to combine with, every fluid which can be uſed to confine it.

The vitriolic acid abſorbs nitrous air, and aſſumes a purple colour. The marine acid imbibes it, and becomes blue. Pale nitrous acid abſorbs it in large quantities, and the colour of the acid changes firſt at the ſurface, and then gradually through the whole of the liquid. The ſucceſſions of colour are, yellow, deep orange, green, and, laſtly, blue, according to the quantities of nitrous air abſorbed. Theſe changes are of the ſame nature as any others, which may increaſe the proportion of phlogiſticated air in the compoſition of the acid. The deep coloured or phlogiſticated acid is more volatile than the pale, and has a greater ſpecific gravity.

But the moſt diſtinguiſhing and characteriſtic property of nitrous air, is the readineſs with which it becomes converted into nitrous acid, whenever it is brought in contact with vital air. In this ſituation it forms red fumes, which are the nitrous acid itſelf in the act of condenſation. This property of nitrous air, by which it combines with, and takes vital air from, the atmoſphere, or from any other reſpirable air, has been applied by Dr. Prieſtley, as a teſt of the purity, or reſpirability of aerial fluids; for the manner of doing which, *ſee* AIR ATMOSPHERICAL. It is ſcarcely neceſſary to repeat, that the red fumes of phlogiſticated nitrous acid conſiſt of nitrous air in the act of uniting with the air of the atmoſphere. The converſion of nitrous air into nitrous acid, by the electric ſpark, has already been mentioned in the preſent article.

According to Mr. Lavoiſier's experiments, the component parts of nitrous air conſiſt of about twenty-one parts, by meaſure, of phlogiſticated air, with forty-three of vital air; and thirty-ſix parts more of vital air are required to change this nitrous air into nitrous acid. Mr. Cavendiſh's experiments ſhew that one part, by meaſure, of phlogiſticated air requires two of vital air, to convert it into nitrous acid. This is a conſiderably greater proportion of the former: but Mr. Lavoiſier reconciles the two reſults, by ſuppoſing that the nitrous acid of Mr. Cavendiſh was of the kind called phlogiſticated.

When nitrous air is expoſed to iron filings and brimſtone, liver of ſulphur, or iron alone, it is gradually diminiſhed, and converted into dephlogiſticated nitrous air. The peculiar property of this air is, that it is fatal to animal life, though a candle will burn in it with an enlarged flame, rather better than in common air. The preſence of water appears to be neceſſary in the production of this ſingular fluid. It is alſo obtained during the ſolution of tin, and of zinc, in the nitrous acid, or by adding iron to the nitrous ſolution of copper. The conſtitution of dephlogiſticated nitrous air has not yet been well explained, and it is even a queſtion whether this air be more or leſs dephlogiſticated than nitrous air itſelf. From its maintaining flame, there can be no doubt but that it contains vital air; but this is no proof that the quantity is greater than in nitrous air, but merely that the conſtitution of this air is ſuch, as to give out its vital air to combuſtible ſubſtances at the temperature of ignition, though at the lower temperature of animal life its preſence may not be exhibited. Dephlogiſticated nitrous air appears, indeed, to contain both nitrous air and vital air, and to participate of the properties of both; but why the two ſhould not unite, and form nitrous acid, remains a difficulty. May not the preſence of inflammable air be one leading cauſe of this? When nitrous air is expoſed, together with moiſture, to iron, the iron is calcined, and, no doubt, emits inflammable

flammable air, whether that air be taken to arife from the iron itfelf, or the water. If, therefore, in this experiment, the quantity of inflammable air which efcapes, fhould unite with the nitrous air, it may form a triple combination, confifting of the very fluid called dephlogifticated nitrous air, which fhould, it feems, poffefs the property of more readily giving out its vital air to a combuftible fubftance, becaufe of the difpofition which the other component parts, namely, inflammable air and phlogifticated air, have to unite, and form volatile alkali; although it may eafily be imagined, that the original compound might not emit its vital air with fufficient facility to fupport animal life, or, if it did, that the fimultaneous production of alkaline air might be attended with noxious effects.

Mr. Milner, whofe curious experiments of the production of nitrous vapours by means of volatile alkali and vital air at a red heat, have been already adverted to, decompofes the nitrous acid, by caufing its vapour to pafs through an ignited gun-barrel, crammed full of iron filings. When the tranfition of the nitrous vapour is rapid, in compariſon to the ignited furface of the iron, which is expofed to calcination by the vital air of the acid, the product confifts of nitrous air and phlogifticated air: when the tranfition is lefs rapid (at a rate not eafily produced and maintained), the product confifts of phlogifticated and nitrous airs, with a mixture of dephlogifticated nitrous air: and laftly, if the ebullition of the acid which fupplies the vapour be very flow, and a fufficient quantity of the iron tube be well heated, the decompofition is almoft complete, and the product confifts almoft entirely of phlogifticated air. It appears, therefore, that the nitrous acid in the order of its decompofition becomes firft nitrous air, then dephlogifticated nitrous air, and, laftly, phlogifticated air; accordingly as it is deprived of a greater quantity of vital air, and probably with the addition of fome inflammable air in the middle ftage of its converfion.

The action of nitrous acid upon combuftible fubftances, is attended with a great variety of curious and inftructive phenomena. With the metals it ufually affords nitrous air, which, in its tranfition through the fuperincumbent acid, produces the various changes of colour already noted. This is elegantly fhewn in the folution of mercury in the nitrous acid. The metal is calcined by the vital air of that part of the acid which was decompofed; while the remaining acid diffolves the calx. Such metals as are more effectually and rapidly calcined, produce a more perfect decompofition of the acid. None are more particularly calculated to fhew thefe effects than tin. According to the ftrength and quantity of the acid, this metal is calcined or diffolved, with the emiffion of nitrous air, of dephlogifticated nitrous air, or without the efcape of any elaftic fluid, at the fame time that volatile alkali is formed in the folution. In thefe cafes, the effects feem to differ, according to the extrication and quantity of inflammable air. When the acid is diluted with half its weight of water, and the tin at the beginning of the procefs is not much calcined, the quantity of inflammable air extricated (either from the tin, as phlogifton, or from the water, by decompofition) is inconfiderable, and nitrous air efcapes. As the operation proceeds, the quantity of inflammable air becomes more conſiderable, and the triple combination of phlogifticated, vital, and inflammable airs, that is to fay, the fluid called dephlogifticated nitrous air, is thrown off. But when, by the action of ftrong acid, the tin is rapidly calcined, without the prefence of much water, either to fupply inflammable air, or latent heat to maintain the elaftic ftate, the whole of the vital air, which is taken from the nitrous acid, enters into the calx of tin; while the whole of the inflammable air, which would elfe have

have been ſet at liberty, combines with the phlogiſticated air of the decompoſed air, and by that means forms volatile alkali.

In the action of nitrous acid upon organized bodies, there are alſo a great number of remarkable effects which take place, both with regard to the elaſtic products and reſidues. When the nitrous acid is applied to the fleſh, or other parts of animal ſubſtances, the elaſtic fluid, which is firſt and moſt plentifully diſengaged, is phlogiſticated air. In this experiment, the phlogiſticated air may come from the animal ſubſtance, or the acid, or both; ſince both contain it. It appears, however, to be much more probable, that the whole comes from the animal ſubſtances. For it is afforded by the application of a very weak nitrous acid, at ſo low a temperature as 65° or 70°; both which circumſtances do not appear to indicate a decompoſition of the acid. The nitrous acid, after its action, ſaturates as large a quantity of alkali as before. The quantity of phlogiſticated air is in proportion to the quantity of volatile alkali which the animal ſubſtance made uſe of affords by diſtillation; and it is known that the quantity of phlogiſticated air contained in any animal ſubſtance muſt be in this proportion. And, laſtly, at a greater heat, after the phlogiſticated air has come over, there is a diſengagement of nitrous air, which indicates a leſs complete decompoſition of the acid than that which would have afforded phlogiſticated air: and it is not conſonant with other chemical facts, that the complete decompoſition of the acid ſhould happen at a lower heat, than the partial decompoſition which ſucceeds it.

The nitrous acid has a very conſiderable action upon vegetable ſubſtances, which it corrodes, or diſſolves, at the ſame time that much nitrous air is diſengaged, together with fixed air. The phenomena are various, according to the nature of the ſeveral ſubſtances. In many inſtances, the reſidue conſiſts of an acid of a different kind from the nitrous, which, according to the proportions of the materials, and management of the proceſs, is either acid of ſugar, or vinegar; or when the deſtruction of the vegetable ſubſtance is moſt complete, fixed air is the product. *See* Acid of Sugar.

In general, when the nitrous acid is mixed with any liquid inflammable matter, it requires to be diluted, and the quantity of this laſt ſhould be very ſmall, and juſt ſufficient to cover the ſurface of the acid; otherwiſe, though the mixture may exhibit no alarming appearance at firſt, it will in a little time become very black, beginning at the ſurface; the vial will then be filled with red fumes, the air will be generated in a prodigious torrent, and unleſs the tube through which it is tranſmitted be ſufficiently wide, and the veſſel in which the mixture is made be very ſtrong, the whole will be exploded with great violence.

When the nitrous acid is mixed with ſpirit of wine, as in the making of nitrous ether, for the management of which proceſs, *ſee* Ether Nitrous, the air produced is very conſiderable in quantity, and burns with a blue or greeniſh flame, very much reſembling that which is produced by a mixture of about $\frac{1}{3}$ of inflammable air, $\frac{2}{3}$ of nitrous air, ſo that probably it conſiſts of both. When a very ſmall quantity of ſpirit of wine * was poured upon a quantity of diluted ſpirit of nitre in a glaſs vial, with a ground ſtopper and tube, a great quantity of air was preſently produced. When a candle was dipped in this air, it was extinguiſhed; but in going out was ſurrounded with a ſlight blue or green flame, though hardly more than is perceived in nitrous air. About one half of this produce of air was

* Prieſtley methodiſed, III. 70.

fixed

fixed air, as appeared by its precipitating lime water, and the remainder was ſtrong nitrous air.

With oil of turpentine, the efferveſcence is very rapid, and ſudden, if ſtrong nitrous acid be uſed; but a great quantity of air is eaſily produced by diluting the ſtrong acid with an equal quantity of water, and cautiouſly heating it, leſt an exploſion ſhould take place, in conſequence of the air being too rapidly extricated. In ſome inſtances, when the production of air is rapid, it is of that kind which is diſtinguiſhed by the name of dephlogiſticated nitrous air. In general, the air conſiſts of nitrous and fixed air in conſiderable quantities, together with a ſmaller proportion of inflammable, and ſome dephlogiſticated nitrous air, together with nitrous acid in vapour.

Dr. Prieſtley did not find that the air produced by applying nitrous acid to the other eſſential oils, was remarkably different from that produced with ſpirit of turpentine.

Ether, both vitriolic and nitrous, heated in nitrous acid, yields the ſame kind of air as the eſſential oils, or ſpirit of wine; namely, partly fixed air, and partly dephlogiſticated nitrous air. Equal caution is alſo neceſſary in conducting this proceſs; for the phenomena attending it are in the higheſt degree dangerous. For this reaſon, it is proper to uſe only a very ſmall quantity of the ether, which is to be poured on the ſpirit of nitre, this laſt being previouſly much diluted.

Olive oil, and alſo tallow, produce nearly the ſame kinds of air as the eſſential oils. The gums, likewiſe, exhibit nearly the ſame phenomena. Camphor affords nitrous air, by the application of a conſiderable degree of heat.

One of the earlieſt known facts of ſpontaneous inflammation, is that produced by the affuſion of the nitrous acid upon oil. All the oils obtained by diſtillation from vegetables, and known by the name of eſſential oils, are proper for this experiment. An ounce of the oil intended to be ſet on fire muſt be placed in a ſhallow veſſel, and a bottle, containing an ounce of the moſt concentrated nitrous acid, muſt be faſtened at the end of a pole, that the operator may be ſufficiently diſtant from the inflammation. Two thirds of the acid being poured on the oil, makes a conſiderable ebullition; the oil growing black and thick, and ſometimes taking fire. But if this laſt circumſtance does not happen in five or ſix ſeconds, the remainder of the acid muſt be poured when the mixture appears moſt dry and black, and then the inflammation ſeldom fails to take place.

Fat oils may alſo be inflamed, if equal parts of the nitrous and vitriolic acids be firſt poured on them, and, when the ebullition is at the greateſt, a portion of nitrous acid be poured on the dryeſt part.

Strong nitrous acid, of the ſpecific gravity of 1.54, being added to the powder of charcoal, or lamp black *, recently made very dry, takes fire, and detonates. There is ſome uncertainty in this experiment; but the method which is ſaid to inſure ſucceſs, is to put the dry powder into a very dry retort, and pour the acid upon the ſide of the glaſs, ſo that it may not fall upon the powder, but flow beneath it.

The production of heat in theſe phenomena, which no doubt ariſes from the action excited between the combuſtible body and the vital air of the acid, has not yet been explained in an adequate manner from experiments tending to ſhew how the capacities of the bodies for heat are changed by the proceſs.

There is ſcarcely any modern improvement in chemical operations of greater va-

* Prouſt, in the Journal de Medecine for July 1788.

lue and importance in the examination of a great variety of bodies, than the application of nitrous acid, which, by repeated abſtraction, converts them into ſeveral acids. This is effected by the readineſs with which the nitrous acid is decompoſed, and ſupplies the requiſite quantity of vital air to the reſpective acidifiable baſes. See the *Acids* of arſenic, of phoſphorus, of vitriol ; alſo, ſulphur, wool.

Many of the opinions reſpecting the component parts of nitrous acid, which were adopted or maintained at the commencement of the modern diſcoveries on air, do not appear at preſent to be inſiſted upon ; and it is now generally admitted, that acids are formed by the union of vital air with combuſtible matter. In the preſent caſe, it is ſufficiently proved, by Mr. Cavendiſh's experiments, that nitrous acid conſiſts of vital and phlogiſticated airs ; and the differences of opinion, in other reſpects, are chiefly grounded upon conſiderations which relate to the ſuppoſed compoſition of the phlogiſticated air. The negative qualities of this laſt ſubſtance are found in the reſidues of moſt aerial fluids, which have been diminiſhed or abſorbed in chemical proceſſes. And from this fact, combined with the ſuppoſition, that all the fluids, diſtinguiſhed by the name of phlogiſticated air, are one and the ſame ſubſtance, it has been inferred that the ſeveral fluids are convertible into phlogiſticated air, which is conſequently taken to be related to them in various ways, according to theories, which being for the moſt part gratuitous, need not be here enlarged upon. The chief inference of this kind, is that which ſuppoſes phlogiſticated air to be a modification of inflammable air, which is ſuppoſed to be combined with a certain due proportion of vital air : ſo that it conſiſts of vital air, phlogiſticated or combined with the inflammable principle. According to this theory *, a larger proportion of the vital air will produce the common air of the atmoſphere, and ſtill greater ſucceſſive additions of vital air will form nitrous air, the aeri-form nitrous acid, the fuming nitrous acid, and the pale nitrous acid. The ſum of this opinion conſiſts, therefore, in ſubſtituting inflammable air in the place of phlogiſticated air; and this ſubſtitution is defended chiefly from the fact, that when water is produced by the combuſtion of vital and inflammable air, there are few caſes in which there is not a production of nitrous acid. The late papers of Dr. Prieſtley, in the Philoſophical Tranſactions (wherein the great quantity of water naturally held in ſolution by the two airs, and the volatility of the nitrous acid, which is uſually of the ſort called highly phlogiſticated, and is not eaſily condenſible in glaſs veſſels, for want of a baſe to combine with, are particularly attended to), render it highly probable, that the ſuppoſed compoſition of water is a fallacy, and likewiſe, that the nitrous acid is compoſed of the two airs in queſtion. But, on the other hand, it is ſtated that this nitrous acid may probably ariſe from a combination of the vital air with a portion of the phlogiſticated air, from which that fluid is never abſolutely free ; though this is denied by Dr. Prieſtley, who did not find that the production of nitrous acid was greater when a larger proportion of phlogiſticated air was added to the mixture.

The properties and habitudes of nitrous acid are explained in almoſt every article of chemical operation.

ACID, PHOSPHORIC. The baſe of this acid, or the acid itſelf, abounds in the mineral, vegetable, and animal kingdoms. In the mineral kingdom it is found in combination with lead, in the green lead ore ; with iron, in the bog ores which afford cold ſhort iron ; and more eſpecially with calcareous earth in ſeveral kinds

* Of Kier. See the expoſition at large, in the article *Acid nitrous*, of his valuable Chemical Dictionary.

of

of ſtone. Whole mountains in the province of Eſtramadura * in Spain are compoſed of this combination of phoſphoric acid and lime. Mr. Bowles affirms that the ſtone is whitiſh, and taſteleſs, and affords a blue flame without ſmell when thrown upon burning coals. Mr. Prouſt deſcribes it as a denſe ſtone, not hard enough to ſtrike fire with ſteel; and ſays that it is found in ſtrata, which always lie horizontally upon quartz, and which are interſected with veins of quartz. When this ſtone is ſcattered upon burning coals, it does not decrepitate, but burns with a beautiful green light, which laſts a conſiderable time. It melts into a white enamel by the blow pipe; is ſoluble with heat, and ſome efferveſcence in the nitrous acid, and forms ſelenite with the vitriolic acid, while the phoſphoric acid is ſet at liberty in the fluid.

The vegetable kingdom abounds with phoſphorus, or its acid. Various ſeeds, potatoes, agaric, ſoot, woods, and charcoal afford phoſphoric acid, by abſtracting the nitrous acid from them, and lixiviating the reſidue. The lixivium contains the phoſphoric acid, which may either be ſaturated with lime by the addition of lime water, in which caſe it forms a ſolid compound, or it may be tried by examination of its leading properties by other chemical methods.

In the animal kingdom it is found in almoſt every part of the bodies of animals, which are not conſiderably volatile. There is not, in all probability, any part of theſe organized beings which is free from it. It has been obtained from blood, fleſh, both of land and water animals; from cheeſe; and it exiſts in large quantities in bones, combined with calcareous earth. Urine contains it, not only in a diſengaged ſtate, but alſo combined with volatile alkali, with mineral alkali, and with lime. It was by the evaporation and diſtillation of this excrementitious fluid with charcoal that phoſphorus was firſt made; the charcoal decompoſing the diſengaged acid, and the volatile alkaline ſalt. *See* PHOSPHORUS. But it is more cheaply obtained by the proceſs of Scheele, from bones, by the application of an acid to their earthy reſidue, after calcination.

In this proceſs the vitriolic acid appears to be the moſt convenient, becauſe it forms a nearly inſoluble compound with the lime of the bones. Bones of beef, mutton, or veal, being calcined to whiteneſs in an open fire, loſe almoſt half of their weight. This muſt be pounded, and ſifted, or the trouble may be ſpared by buying the powder that is ſold to make cupels for the aſſayers, and is, in fact, the powder of burned bones ready ſifted. To three pounds of the powder, there may be added about two pounds of concentrated vitriolic acid. Four or five pounds of water muſt be afterwards added to aſſiſt the action of the acid; and during the whole proceſs the operator muſt remember to place himſelf and his veſſels ſo that the fumes may be blown from him. The whole may be then left on a gentle ſand bath for twelve hours or more, taking care to ſupply the loſs of water, which happens by evaporation. The next day a large quantity of water muſt be added, the whole ſtrained through a ſieve, and the reſidual matter, which is ſelenite, muſt be edulcorated by repeated affuſions of hot water, till it paſſes taſteleſs. The waters contain phoſphoric acid nearly free from lime, and by evaporation, firſt in glazed earthen, and then in glaſs veſſels, afford the acid in a concentrated ſtate, which by the force of a ſtrong heat in a crucible, may be made to acquire the form of a tranſparent conſiſtent glaſs, though indeed it is uſually of a milky, opake appearance.

For making phoſphorus, it is not neceſſary to evaporate the water farther than

* Annales de Chimie, I. 196. Alſo, Kier's Dictionary, and the authors by him quoted.

to bring it to the conſiſtence of ſyrup; and the ſmall portion of lime it contains is not an impediment worth the trouble of removing, as it affects the produce very little. But when the acid is required in a purer ſtate, it is proper to add a quantity of mild volatile alkali, which, by double elective attraction, precipitates the lime which was held in ſolution by the phoſphoric acid: that is to ſay, the volatile alkali unites with the phoſphoric acid, while the fixed air unites with the lime, and cauſes it to fall down in the form of the indiſſoluble compound, chalk. The fluid being thus evaporated, affords a cryſtallized ammoniacal ſalt, which may be melted in a ſilver veſſel, as the acid acts upon glaſs or earthen veſſels. The volatile alkali is driven off by the heat, and the acid acquires the form of a compact glaſs as tranſparent as rock cryſtal, acid to the taſte, ſoluble in water, and deliqueſcent in the air.

This acid is very pure, but nevertheleſs may contain a ſmall quantity of mineral alkali, originally exiſting in the bones, and not capable of being taken away by this proceſs, ingenious as it is. The only unequivocal method of obtaining a pure acid appears to conſiſt in firſt converting it into phoſphorus by diſtillation of the materials with charcoal, and then converting it again into acid by combuſtion, or ſome other equivalent proceſs.

If a number of ſticks of phoſphorus be placed upright in a glaſs funnel, a piece of glaſs being previouſly put into the neck of the funnel to prevent their falling through; and if this funnel be then inſerted in the neck of a bottle, containing diſtilled water, the phoſphorus will be gradually decompoſed by a ſlow combuſtion, provided it be expoſed to a temperature not much lower than 60°. The phoſphoric acid will gradually paſs through the funnel into the water. The acid obtained, contains a portion of phoſphorus; but by expoſure to the air, this alſo becomes converted into acid: or the ſuperfluous portion of phoſphorus may be burned, by cauſing the fluid to boil. This may be concentrated by evaporation of the water if required, and may, like every other ſolution of this acid, be reduced to the concrete or glacial form, by a ſufficient degree of heat. This glacial acid is deliqueſcent, though it is ſaid, that a ſtronger heat will deprive it of ſolubility, and acidity; moſt probably in conſequence of a ſolution of part of the earth of the retort or crucible.

Phoſphorus may alſo be converted into the acid ſtate by treating it with nitrous acid. In this operation, a tubulated retort, with a ground ſtopper, muſt be half filled with nitrous acid, and a gentle heat applied. A ſmall piece of phoſphorus being then introduced through the tube, will be diſſolved with effervеſcence, produced by the eſcape of a large quantity of nitrous air. The addition of phoſphorus muſt be continued until the laſt piece remains undiſſolved. The fire being then raiſed to drive over the remainder of the nitrous acid, the phoſphoric acid will be found in the retort, partly in the concrete, and partly in the liquid form.

Vitriolic acid produces nearly the ſame effect as the nitrous; a large quantity of phlogiſticated or ſulphureous vitriolic acid flying off. But as it requires a ſtronger heat to drive off the laſt portions of this acid, it is not ſo well adapted to the purpoſe.

When phoſphorus is burned by a ſtrong heat, ſufficient to cauſe it to flame rapidly, it is almoſt perfectly converted into dry acid, ſome of which is thrown up by the force of the combuſtion, and the reſt remains upon the ſupporter.

This ſubſtance has alſo been acidified by the direct application of vital air paſſed through hot water, in which the phoſphorus was liquefied or fuſed.

When a ſtick of phoſphorus is plunged in the ſolutions of gold, ſilver, copper,

and

and other metals, the phoſphorus gradually receives vital air from the metallic calx, and becomes acidified, while the metal reſumes its reguline ſtate, and forms a brilliant ſheath of revived metal ſurrounding the remaining phoſphorus.

The general characters of phoſphoric acid, are, 1. It is ſoluble in water in all proportions, producing a ſpecific gravity, which increaſes as the quantity of acid is greater, but does not exceed 2687:1000, which is that of the glacial acid. 2. It produces heat when mixed with water, though not very conſiderable. 3. It has no ſmell when pure, and its taſte is ſour, but not corroſive. 4. When perfectly dry, it ſublimes in cloſe veſſels; but loſes this property by the addition of water, in which circumſtance it greatly differs from the acid of borax, which is fixed when dry, but riſes by the help of water. 5. When conſiderably diluted with water, and evaporated, the aqueous vapor carries up a ſmall portion of the acid. 6. With charcoal or inflammable matter, in a ſtrong heat, it loſes its acidity, and becomes converted into phoſphorus.

When liquid phoſphorus is heated, no part of the vapour retains the aerial or permanently elaſtic form; neither does it afford air by boiling with mercury, or even ardent ſpirit. But it readily diſſolves iron, with the aſſiſtance of a little heat, with which it affords a ſtrong inflammable air. But the effect of adding the acid of phoſphorus to minium is highly ſingular, and by no means eaſy to be explained. When all the air has been expelled from minium, which mere heat can drive out, this ſubſtance yields vital air when heated with nitrous air, but no air at all with the vitriolic or marine acids. The phoſphoric acid (produced by deliqueſcence or ſlow combuſtion) mixed with this minium, with little or no ſenſible heat; but the mixture expoſed to the flame of a candle yielded air very plentifully, and it was very turbid. It did not precipitate lime water over which it was received, except in the ſmalleſt degree. Neither was it affected by nitrous air, nor did it affect common air; but was ſtrongly inflammable, burning with a bright white flame, and the ſmell of the air was the ſame with that of the ſtrong ſmell of phoſphorus. The calx or maſſicot * became of a darkiſh grey colour, or nearly black, by this proceſs.

The phoſphoric acid does not appear to act upon ſiliceous earth in the humid way, though it has been obſerved to corrode glaſs when hot. In the dry way, it acts upon all the earths. With calcareous earth, in the humid way, it forms a gummy maſs, containing ſome cryſtals, but the greateſt part of the maſs takes a pulverulent form, and ſubſides. This compound is ſcarcely ſoluble in water, unleſs by virtue of an exceſs of acid. It does not differ from the white earth of calcined bones. Phoſphoric acid, added to a marine ſolution of ponderous earth, ſeizes this laſt, and falls with it to the bottom in an inſoluble precipitate. With magneſia, it likewiſe forms a cryſtallizable compound of very difficult ſolubility. It alſo unites with clay or earth of alum, forming an inſoluble ſaline powder, and a fluid which, by evaporation, yields a gritty powder, and a thick gummy ſolution, convertible by heat into a tranſparent glaſs.

This acid, when in combination with the vegetable alkali, forms a very ſoluble ſalt, which is much more ſoluble in hot than in cold water, and may be obtained in cryſtals, either by cooling or evaporation. It decrepitates in the fire, and afterwards melts without decompoſition. The combination of mineral alkali with phoſphoric acid, forms a gummy fluid not eaſily cryſtallized, unleſs there be a ſmall exceſs of alkali, in which caſe it effloreſces by expoſure to a dry air. The taſte of this ſalt not being nauſeous, but conſiderably reſembling that of common ſalt,

* Prieſtley, ed. 1790. III. 293.

it

it has lately been introduced into medical practice as a cathartic. When urine is evaporated, this ſalt is among its products; and as it is not decompoſable by the dry way with charcoal, it was at firſt conſidered as a peculiar ſubſtance, and diſtinguiſhed by the name of the perlate ſalt or acid.

The volatile alkali forms, with the acid of phoſphorus, a cryſtallizable ſalt, which when obtained in an impure ſtate from urine, by evaporation, has been called microcoſmic ſalt, and is of great uſe in experimental aſſays by the blow-pipe. It is more ſoluble in hot than in cold water, and cryſtallizes moſt eaſily when the alkali is rather in exceſs. A gentle heat decompoſes it, when diſſolved in water, and cauſes part of its alkali to fly off, ſo that it cannot eaſily be purified by cryſtallization, unleſs by ſolution, and cooling in cloſed veſſels.

Phoſphoric acid does not act in the humid way upon gold, ſilver, platina, or mercury; but it formed a purple ſcoria when fuſed with gold leaf. It ſcarcely acts on copper, unleſs, perhaps, by the aſſiſtance of the air in proceſs of time. It corrodes tin, at the ſame time that it emits an offenſive ſmell. The calx of this metal is in ſome degree ſoluble in it, and is ſo far changed as to be rendered very fuſible. Lead is a little corroded by the phoſphoric acid. Neither mercury nor its calces are ſoluble in it; but it changes red precipitate to a yellow and white colour, and laſtly, by long digeſtion, to black. The white calx of arſenic is completely diſſolved, but not the regulus. Zinc, likewiſe, is perfectly diſſolved, and affords by evaporation a gummy maſs, which runs by fuſion into a tranſparent glaſs. Regulus of antimony is diſſolved in a ſmall proportion, as are alſo biſmuth and its calx, and the calx of nickel. With regulus of manganeſe it forms a white ſolution, and a red ſolution with the calx, which, however, becomes white on expoſure to the air.

The action of phoſphoric acid in the dry way is much more powerful. With ſome of the moſt calcinable metals, eſpecially with tin, lead, iron, and zinc, it becomes partly converted into phoſphorus; and with moſt of them this converſion takes place if charcoal be preſent, in which caſe the phoſphorus combines with the metal. *See* PHOSPHORUS. When the phoſphoric acid is combined with iron, its effects are ſuch as deſerve the moſt particular attention. In the humid way, it is readily diſſolved, with effervеſcence, and the diſengagement of inflammable air; and the ſolution affords permanent cryſtals, provided the acid be rather in exceſs; but if the acid be more abundant, the product is a dry adheſive maſs, which falls to the bottom, and is inſoluble in water, but ſoluble in ardent ſpirit, or in the diluted vitriolic acid. It has already been mentioned that the compound of phoſphoric acid and iron in the bog ores renders the metal cold-ſhort: for the particulars of which the article IRON may be conſulted.

Though the phoſphoric acid is ſcarcely corroſive, yet, when concentrated, it acts upon oils, which it diſcolours, and at length blackens, producing heat, and a ſtrong ſmell like that of ether and oil of turpentine; but does not form a true acid ſoap. It has moſt effect on eſſential oils, leſs on drying oils, and leaſt of all on fat oils. Spirit of wine and phoſphoric acid have a weak action on each other. Some heat is excited by this mixture, and the product which comes over in diſtillation of the mixture is ſtrongly acid, of a pungent arſenical ſmell, inflammable with ſmoke, miſcible in all proportions with water, precipitating ſilver and mercury from their ſolutions, but not gold; and although not an ether, yet it ſeems to be an approximation to that kind of combination *.

* Chimie de Dijon, III. 338.

The

The theory of the phoſphoric acid, as far as relates to its component parts, is perfectly ſimilar to that of the other acids, which have hitherto been ſucceſsfully examined. Phoſphorus is the combuſtible ſubſtance, which by combuſtion abſorbs vital air, and becomes converted into an acid: and on this occaſion, the two theories of chemiſtry ſtand preciſely on the ſame ground as has been explained in the general article on ACIDS. The phoſphorus, conſidered as a ſimple body, unites with the vital air, likewiſe conſidered as ſimple; or elſe, by a greater refinement of explanation, the phoſphorus parts with phlogiſton, while its acidifiable baſis unites with vital air, and forms acid; or, laſtly, if the vital air itſelf be ſuppoſed to be a compound, the explanation will become ſtill leſs ſimple, and will vary according to the gratuitous poſitions which may be introduced into the theory.

ACID OF PRUSSIAN BLUE. The habitudes of the colouring matter of Pruſſian blue denote it to be an acid. *See* PRUSSIAN BLUE. If the Pruſſian blue be boiled with an alkali, the colouring matter immediately quits the iron, to combine with the ſalt, and from this alkali the colouring matter or acid may be extricated by boiling in a retort with diluted acid of vitriol. The colouring matter comes over in the form of an inflammable air, which will be abſorbed by water placed for that purpoſe in the receiver. As a portion of vitriolic acid, likewiſe, comes over, a ſecond diſtillation is neceſſary to be made, with the addition of chalk. The vitriolic acid, by this means, forming ſelenite, is detained; while the Pruſſian acid paſſes over totally, before one fourth of the water is diſtilled off.

The colouring matter of Pruſſian blue is not only ſeized by the fixed alkalis, but likewiſe by the volatile alkali, by lime, by magneſia, and by ponderous earth; with which it forms peculiar compounds, capable of precipitating Pruſſian blue, by double affinity, from the ſolutions of iron in acids. Various metals, likewiſe, combine with it. Alkalis, or lime, combined with the Pruſſian acid, are uſed as teſts to aſcertain the preſence and quantity of iron in ſolutions. But all the alkaline or earthy combinations, produced by boiling thoſe ſubſtances with Pruſſian blue, contain iron, which falls down in the form of the blue precipitate when an acid is added. For this reaſon, they cannot be uſed in accurate experiments, unleſs a previous trial has been made of the quantity a known proportion of the proof liquor is capable of precipitating.

If the dephlogiſticated or aerated marine acid be mixed with the Pruſſian acid, the former reſumes the ſtate of common marine acid; while the latter acquires a much ſtronger ſmell, and appears to be more volatile. In this ſituation, it does not form Pruſſian blue with the ſolutions of iron; but affords a green precipitate, which becomes blue by expoſure to the light, or by the addition of volatile vitriolic acid.

If martial vitriol be added to the dephlogiſticated or aerated marine acid, and a ſolution of Pruſſian alkali be poured in, the green precipitate which is formed is again diſſolved; but it may be precipitated of a blue colour by the addition of volatile vitriolic acid, or martial vitriol, or iron alone.

In the inſtances laſt mentioned, we may perceive that the effects depend on the dephlogiſtication or addition of vitalair, to the Pruſſian acid, accordingly as we adopt the ancient or the modern theory. The green precipitate, which may be conſidered either as dephlogiſticated Pruſſian blue, or as Pruſſian blue combined with vital air, becomes common Pruſſian blue by the action of light, which, as we have frequently had occaſion to remark, operates, in many inſtances, in a manner contrary to that of combuſtion; that is to ſay, it either adds phlogiſton, or expels vital air, or does both. By this action, therefore, the Pruſſian blue returns to its original ſtate. The addition of volatile vitriolic acid muſt produce a like effect; for this acid is phlo-

giſticated according to the old theory, or is deficient in vital air according to the new: it is therefore diſpoſed either to phlogiſticate the green precipitate, or to attract vital air from it; which is all that it requires to convert it into common Pruſſian blue. The ſame theories manifeſtly apply to the green precipitate, which is redilſolved: for in whatever ſtate of combination it may be ſuppoſed to remain, as to the order or arrangement of the principles which are united in the fluid, the addition of volatile vitriolic acid, or common vitriol, or iron in the metallic ſtate, will impart phlogiſton, or attract vital air; the abſence of the one, or the redundance of the other of which, is ſuppoſed, according to the reſpective theories, to cauſe the difference between it and Pruſſian blue.

If the Pruſſian acid be impregnated more ſtrongly with the dephlogiſticated or aerated marine acid, and then expoſed to the action of light, it aſſumes new properties. It no longer combines with iron precipitated from its ſolutions; its ſmell is entirely different from that which it before poſſeſſed, and now reſembles an aromatic oil, the greateſt part of it ſeparating from the water, at the bottom of which it flows in the form of an oil. This fluid, however, is not inflammable. By a gentle heat it riſes in the form of a vapour, not ſoluble in water: and in time it aſſumes the form of ſmall cryſtals. Pruſſian acid cannot be reſtored after it has undergone theſe changes.—Their theory is not known.

Various experiments have been made to diſcover the component parts of the Pruſſian acid. If equal parts of pulverized charcoal and vegetable alkali be made red hot for a quarter of an hour in a crucible, and ſome ſal ammoniac in ſmall pieces be then briſkly ſtirred down into the maſs, the ammoniacal vapours will ſoon ceaſe. The ignited matter being then thrown into water, affords a lixivium equal to the beſt which is made with blood. From theſe, and other experiments, it was concluded, that its component parts are fixed air, volatile alkali, and the principle of inflammability, or phlogiſton. Later experiments appear to have decided the queſtion ſomewhat more accurately. When the acid has been converted, by means of the dephlogiſticated or aerated marine acid, into that ſtate which affords a green precipitate with iron, it emits alkaline air upon the addition of lime, or a pure alkali. If the lime, or alkali, be afterwards ſaturated by the addition of ſome other acid, the Pruſſian acid is not diſengaged, or reſtored, but is no where found; hence it follows, that the alkaline air was one of the principles of the Pruſſian acid, which is deſtroyed: and as the lime or alkali uſed in this decompoſition is found to be in a mild ſtate, that is to ſay, combined with fixed air, though it did not contain that ſubſtance before; it is clear that the other principle of the Pruſſian acid is fixed air. The common Pruſſian acid conſiſts, therefore, of volatile alkali, united with the baſe of fixed air, or that ſubſtance which, in combination with vital air, forms the acid called fixed air. When the Pruſſian acid receives vital air, and is converted into the ſtate proper to afford the green precipitate; it then appears to conſiſt of the ſame principles as the mild or concrete volatile alkali, though probably in a different order of combination, and this order ſeems to be deranged by the addition of the lime, or the fixed alkali, which attracts thoſe principles that form fixed air, at the ſame time that the principles which form volatile alkali fly off in the elaſtic ſtate.

The component parts of Pruſſian acid will conſequently be phlogiſticated air, inflammable air, and fixed air, or its baſe; all which are afforded by animal ſubſtances; but they do not form this peculiar combination in any caſe yet known, excepting that in which an alkali is preſent, when thoſe ſubſtances are decompoſed by fire.

ACID OF SORREL. This acid is obtained from the ſalt of ſorrel, and does not

not in any reſpect differ from the acid of ſugar, or ſaccharine acid. The ſalt of ſorrel is a cryſtallized ſalt; ſo denominated, becauſe it is obtained from the wood ſorrel, or oxalis acetoſella of Linnæus, for the purpoſes of commerce; though it may be obtained from ſome other plants. It is in white cryſtals, whoſe figure has not been well determined, on account of their minuteneſs. When it is expoſed to diſtillation in a retort, the acid is partly decompoſed; a conſiderable quantity of acid phlegm comes over, which is without ſmell or colour, and conſiſts of the acid itſelf, ſcarcely altered; and the reſidue affords vegetable alkali, amounting to ſomewhat more than one third of the weight of the ſalt. Expoſure to air does not alter the ſalt of ſorrel. It is very ſparingly ſoluble in cold water: but boiling water may take up one ſixth, or more, of its weight; the quantity varying according to the ſtate and purity of the ſalt, which ſeems to vary in different ſpecimens.

Salt of ſorrel acts upon various ſubſtances without decompoſition. With ponderous earth, magneſia, vegetable alkali, and volatile alkali, it forms triple ſalts. Lime decompoſes it, by ſeizing the whole of the acid, and diſengaging the alkali. The attraction of this acid for lime is ſo ſtrong, that it cannot be diſengaged from it by any other acid: another proceſs is therefore neceſſary to be uſed for obtaining it. With this intention, the ſuperabundant acid is to be ſaturated with volatile alkali; and into this ſolution muſt be poured a ſolution of ponderous earth in the nitrous acid. The laſt mentioned acid combines with the alkalis, forming nitrous ammoniac and common nitre, both which remain in ſolution; while the ponderous earth combining with the acid of ſorrel, forms an inſoluble compound, which falls to the bottom. This precipitate, after being well waſhed, may be decompoſed by the addition of vitriolic acid, which ſeizes the earth, and likewiſe forms an inſoluble combination, while the acid is ſet at liberty. After decantation of the clear liquid, it muſt be aſſayed by pouring into it a little at a time of the boiling hot ſolution of ponderous earth in the acid of ſorrel. If there be any exceſs of vitriolic acid, a precipitate will be formed by its union with the ponderous earth. A due evaporation and cooling of this liquor afford the acid of ſorrel or ſaccharine acid, in priſmatic four-ſided cryſtals or ſquare plates.

ACID OF SUGAR, *or* SACCHARINE ACID. This acid is ſo denominated, becauſe it was firſt obtained from ſugar when ſubmitted to chemical examination. The proceſs of Bergman is as follows: Three ounces of ſtrong nitrous acid, whoſe ſpecific gravity was nearly 1.567, were mixed in a tubulated retort with one ounce of the fineſt ſugar in powder. Much nitrous air eſcaped in red fumes, formed by combination with the vital air of the atmoſphere. A receiver was then adapted, and the liquor gently boiled. As ſoon as the mixture had acquired a dark brown colour, three additional ounces of nitrous acid were added, and the boiling was continued until the coloured and fuming acid had entirely diſappeared. The liquor being then poured out, afforded ſmall priſmatic cryſtals by cooling, which weighed 109 grains, and are the acid of ſugar. The remaining lixivium being again treated in the ſame manner, with two ounces of nitrous acid afforded an additional portion, conſiſting of forty-three grains of acid of ſugar, which ſeparated by cooling; and the remaining glutinous liquor being treated at different times with ſmall quantities of nitrous acid, amounting in the whole to two ounces, and evaporated to dryneſs, afforded a ſaline maſs, brown, glutinous, and deliqueſcent, which, when perfectly dried, weighed half a dram: and, laſtly, the whole was depurated by repeated ſolutions and cryſtallizations in water. In this way, with three parts of ſugar and thirty of nitrous acid, the quantity of one part of acid of ſugar is obtained.

It may be obſerved, that a weaker nitrous acid will anſwer the purpoſe nearly as

well as the concentrated acid; and that where it is not an object to collect the acid which comes over, there will be no need of any receiver or other apparatus, except a matraſs or Florence flaſk to perform the operation in a chimney where there is a proper draft of air to carry off the acid fumes.

It has been diſcovered, ſince the original experiments of Scheele and Bergman, that a variety of other ſubſtances afford the nitrous acid when treated in the above manner. Bergman procured it from honey, gum arabic, ſpirit of wine, and the calculous concretions in the kidneys and bladders of animals; Scheele and Hermbſtadt from ſugar of milk. Scheele from a ſweet matter contained in fat oils, and alſo from the uncryſtallizable part of the juice of lemons. Hermbſtadt from the acid of cherries, and the acid of tartar. Gottling from beech wood. Kohl from the reſiduum in the diſtillation of ardent ſpirits. Weſtrumb not only from the cryſtallized acids of currants, cherries, citrons, raſpberries, but alſo from the ſaccharine matter of theſe fruits, and from the uncryſtallizable parts of the acid juices. Hoffman from the juice of the common barberry; and Berthollet from ſilk, hair, tendons, wool; alſo from other animal ſubſtances, eſpecially from the coagulum of blood, whites of eggs, and likewiſe from the amylaceous and glutinous parts of flour *.

Mr. Berthollet obſerves, that the quantity of the ſaccharine acid obtained by treating wool with nitrous acid was very conſiderable, having got above half its weight of ſaccharine acid; whereas Bergman obtained only one third from the ſugar employed. He mentions a difference which he obſerved between animal and vegetable ſubſtances thus treated with nitrous acid, namely, that the former yielded, beſides volatile alkali, a large quantity of an oil, which the nitrous acid could not decompoſe; whereas the oily parts of vegetables were totally deſtroyed by the action of this acid: and he remarks, that in this inſtance the glutinous part of flour reſembled animal ſubſtances, whereas the amylaceous part of the flour retained its vegetable properties. He further remarks, that the quantity of ſaccharine acid furniſhed by vegetable matters is proportionable to their nutritive quality, and particularly that from cotton he could not obtain any ſenſible quantity.

Theſe cryſtals of acid of ſugar have an exceedingly pungent taſte, but, when ſufficiently diluted with water, their taſte is agreeable. It converts all blue vegetable juices, except that of indigo, to a red. It expels fixed air from alkalis and earths, and conſequently effervеſces with them if they be in the mild ſtate. Boiling diſtilled water diſſolves its own weight of the cryſtals, though in a heat of ſixty degrees it diſſolves only half of that quantity. The ſolution at firſt appears a little turbid, but ſoon recovers a perfect tranſparency. The ſpecific gravity of this laſt ſolution, when ſaturated, is 1.0593. The vapours which ariſe during the boiling of the former ſolution do not contain any acid, and the liquor as it cools gradually depoſits a great quantity of cryſtals, many of which exhibit priſms diverging from a point.

Theſe cryſtals of acid of ſugar are ſoluble in other acids. Concentrated vitriolic acid ſeizes the oily matter and grows brown, and at length totally conſumes the cryſtals, eſpecially on boiling; but when diluted, though it diſſolves the cryſtals readily, yet it yields them up again, but in the form of needles, a change which this acid likewiſe produces with other ſalts. The nitrous acid readily takes up the acid of ſugar, and upon boiling grows yellow. Upon cooling, the cryſtals are again ſeparated, but generally irregular and leſs in quantity. If the ſolution be often repeated with the aſſiſtance of heat, the ſaccharine acid is totally deſtroyed.

* Keir's Chemical Dictionary, page 161.

The

The marine acid and vinegar diſſolve the cryſtals very completely, but do not produce any change in their properties.

One hundred parts of ſpirit of wine take up nearly fifty-ſix of this acid at a boiling heat, but not above forty in a moderate heat. This ſolution becomes ſomewhat turbid, and depoſits a mucous ſediment, equal to nearly one fortieth of the acid. On cooling, ſcaly cryſtals are ſeparated, of an irregular form and fragrant ſmell, which grow white in drying. Two drams of the cryſtals diſſolved in the ſame quantity of ardent ſpirit, of the ſpecific gravity of 0.8581, were boiled over a ſlow fire in a ſmall retort. The firſt half dram which came over was nothing but the ſpirit deprived of its ſuperfluous phlegm; after which ſtriæ began to appear in the retort, and a dram of an acid liquor came over, which upon evaporation yielded a cryſtallized ſaccharine acid. Upon the addition of lime-water, the ſaline combination of acid of ſugar and lime fell to the bottom, and on the top there floated a thin ſtratum of ether, which differs much from the common ether, for it has but a weak ſmell, is not inflammable except when hot, and does not burn with a white, but with a blue flame, only white on the ſurface.

Vitriolic ether diſſolves the cryſtallized acid of ſugar, but with difficulty. Oils, both eſſential and expreſſed, diſſolve it; but it ſeparates upon due evaporation of the former, or in a more violent heat of the latter it ſeparates by riſing above the ſurface.

This acid effloreſces in an heat exceeding 60°, the cryſtals loſing about three tenths of their weight by falling into a white powder. This loſs, which conſiſts merely of water of cryſtallization, is quickly recovered in a moiſt air.

When the acid of ſugar is expoſed to heat in low diſtilling veſſels, the water of cryſtallization firſt comes over in the quantity above ſpecified. As the heat becomes greater, the acid melts, and grows brown when boiling hot: a little phlegm comes over: an acid powder effloreſces upon the luting of the receiver, and a white ſaline cruſt ſublimes, which conſiſts of acid of ſugar in a very pure ſtate. The reſiduum is of a brown or grey colour, and empyreumatic ſmell, and flies off if expoſed to the fire in an open veſſel. In the receiver is found an acid liquor, which has the properties of acid of ſugar, but does not eaſily cryſtallize. During this operation a great part of the acid of ſugar is deſtroyed, and a large quantity of aerial fluid eſcapes, which on examination is found to conſiſt of about one half fixed air abſorbable by lime water, and the reſt heavy inflammable air, which burns with a blue flame. If the ſublimed acid of ſugar be again and again expoſed to heat, its decompoſition is ſtill farther effected, and more ſpeedily in open than cloſe veſſels. It affords no veſtiges of coal; a circumſtance that diſtinguiſhes it from the acid of tartar.

The combination of acid of ſugar with vegetable alkali does not eaſily afford cryſtals when ſaturated; but if either the acid or alkali be rather in exceſs, the ſolution affords cryſtals without difficulty. Two parts of perfectly mild alkali being combined with one of ſaccharine acid, and carefully evaporated, afford beautiful priſmatic cryſtals, nearly of the ſame form as thoſe of the acid itſelf, which are very ſoluble in water, but leſs ſo in ardent ſpirit. Lime, ponderous earth, or magneſia, ſeparate the acid from theſe cryſtals. As the ſaccharine acid has a ſtronger attraction for lime than any other acid has, and forms an inſoluble compound with that earth, it is uſed as a teſt to diſcover its preſence in all ſolutions: and though the acid alone is capable of throwing down this inſoluble compound, yet the combination of acid of ſugar and vegetable alkali operates more ſpeedily by means of the double affinity.

Two parts of newly cryſtallized mineral alkali, combined with one of ſaccharine acid, form a ſalt of very difficult ſolubility; part of which falls down at the time of combination, and the remaining ſolution affords cryſtals which diſſolve perfectly in warm water, but not in ardent ſpirit. In its other properties this ſalt reſembles that formed with the vegetable alkali; but the mineral alkali is expelled by the vegetable.

The combination of acid of ſugar with volatile alkali affords quadrangular priſmatic cryſtals by ſlow evaporation, which are ſoluble in water, but not in ardent ſpirit. By deſtructive diſtillation they afford, firſt, a concrete or mild volatile alkali, and then a portion of volatile alkali combined with acid of ſugar. A coaly reſiduum is left, which indicates a decompoſition of the ſalt; and the mild ſtate of the volatile alkali which firſt comes over, ſhews that a portion of fixed air was extricated, no doubt, from the acid of ſugar. Fixed alkalis and the ſoluble earths decompoſe this ſalt.

Eighty-two parts of ſaccharine acid diſſolve one hundred of tranſparent calcareous ſpar, though ſlowly, becauſe the firſt action of the acid on the lime forms a nearly inſoluble compound, which covers and in ſome meaſure defends the internal parts of the ſpar. When lime is diſſolved in nitrous acid, it is completely precipitated by acid of ſugar, in the form of a white powder not ſoluble in water. Of 119 parts by weight of this powder, 72 fall to the bottom, and 47 appear upon evaporation. Hence it appears that 100 parts contain of acid 48, of pure lime 46, and of water 6; ſo that not only the preſence of lime in water may be diſcovered, but alſo its quantity, from the weight of the precipitate.

The acid of ſugar, ſaturated with ponderous earth, is very ſparingly ſoluble in water, and does not cryſtallize unleſs the acid be in exceſs. Hot water takes away this ſuperabundant acid from part of the cryſtals, and therefore throws down a precipitate; pure vegetable alkali cauſes a precipitate for the ſame reaſon, namely, becauſe it ſeizes the ſuperabundant acid. The cryſtals of this ſalt are ſcarcely ſoluble in ardent ſpirit.

Magneſia likewiſe forms a ſalt with the acid of ſugar, which is not ſoluble either in water or ardent ſpirit, unleſs the acid be ſuperabundant. One hundred parts of this ſalt contain 35 of pure magneſia, and 65 of acid and water. The fluor acid is the only one which decompoſes this ſalt: lime and ponderous earth likewiſe ſeize its acid; but alkalis do not.

Of pure clay, or earth of alum, well waſhed, forty-two parts are diſſolved by digeſtion with 53 of acid of ſugar. This ſolution does not afford cryſtals by evaporation, but a yellowiſh pellucid maſs of a ſweet though aſtringent taſte; which when dry deliquates in a moiſt air, and gains $\frac{2}{3}$ of its weight. This reddens tincture of turnſole, but not ſyrup of violets. It is ſparingly ſoluble in ſpirit of wine; ſwells in the fire, and loſes its acid, a brown earth remaining behind. One hundred parts of this argillaceous ſalt contain about 44 of earth, and 56 of acid and water. It is decompoſed by the vitriolic, nitrous, and marine acids, the alkaline ſalts, ponderous earth, lime, and magneſia.

No action takes place between the ſolution of ſaccharine acid and gold in the metallic ſtate; but if the metal be precipitated by an alkali from its ſolution in aqua regia, and then well waſhed, the ſaccharine acid blackens, but ſcarcely diſſolves it. Platina is not diſſolved, unleſs precipitated by an alkali. When this metal is precipitated by the mineral alkali, and well waſhed, it forms a yellow ſolution with the acid of ſugar, which affords yellow cryſtals. Silver is not attacked by the acid of ſugar, and its precipitate by an alkali is very feebly acted on. If the ſaccharine

acid

acid be added to a nitrous ſolution of ſilver, it ſeizes the metal, with which it falls down in the form of a white powder, ſcarcely ſoluble in water, and ſtill leſs in ardent ſpirits, but ſoluble in the nitrous acid. This powder when well waſhed does not change even the tincture of turnſole. The rays of the ſun convert it to a black colour. The ſolution of ſilver in the vitriolic acid is alſo decompoſed by acid of ſugar, but the marine ſolution does not appear to be decompoſable.

Mercury is not acted upon by the ſaccharine acid, unleſs it be in the ſtate of calx, and in this caſe it is diſſolved, forming a powdery white ſalt, which is not ſoluble in water, unleſs the acid predominates, and which grows black by expoſure to the ſun's rays. The ſame combination may be had by adding ſaccharine acid to the nitrous ſolution of mercury. The precipitate afforded in this way by corroſive ſublimate does not grow black in the ſun. Lead in the metallic ſtate is corroded, but ſcarcely diſſolved in this acid, unleſs it be calcined, eſpecially by precipitation with an alkali. The ſolution lets fall ſaline grains as it approaches towards ſaturation. The ſame combination may be had by adding the ſaccharine acid to the nitrous, marine, or acetous ſolutions of lead. The cryſtals are not ſoluble in ardent ſpirit, and ſcarcely in water, unleſs it be ſharpened with an acid. The cryſtals contain about 55 parts of lead in the hundred. Lead is not precipitated from the vitriolic by the ſaccharine acid. Copper in its metallic ſtate is attacked by the acid of ſugar, but more readily if it has been precipitated by an alkali. The ſolutions form a powder of a faint blue colour ſparingly ſoluble in water, unleſs the acid be in exceſs. The cupreous ſolutions in vitriolic, nitrous, or marine acids, are precipitated by ſaccharine acid; and the ſolution of the acetous ſalt of copper is ſo completely decompoſed by this acid, that the concentrated vinegar remains with a very ſmall portion of copper in ſolution. Iron, whether metallic or calcined, is ſoluble in the acid of ſugar. The ſolution of metallic iron is attended with efferveſcence and the eſcape of inflammable air, and affords cryſtals with a ſuperabundance of acid, and ſoluble in water. Tin is ſlowly diſſolved, as is likewiſe its calx more readily. Both ſolutions poſſeſs an exceſs of acid, and the former exhibits cryſtals.

Regulus of biſmuth is ſomewhat corroded by the acid of ſugar, but the calx only is diſſolved, forming a powdery white ſalt, very ſparingly ſoluble in water, and containing half its weight of metal. If ſaccharine acid be added to the nitrous ſolution of biſmuth, there will be formed, in the ſpace of half an hour, tranſparent polygonal grains, which have the ſame properties as the powdery white ſalt, and do not occaſion opacity in water, as the cryſtals of the nitrous ſalt of biſmuth do. Nickel is converted, by digeſtion with ſaccharine acid, into a greeniſh white powder, as is alſo the green calx of this ſemi-metal, without the aſſiſtance of heat. This combination contains twice as much acid as metal. The ſaccharine acid precipitates a powder of the ſame kind from the vitriolic, nitrous, or marine ſolutions of nickel. This ſalt is ſoluble in a large quantity of water, and aſſumes a yellow colour. Reguline arſenic is ſcarcely diſſolved by digeſtion in acid of ſugar; but the white calx is eaſily taken up without heat. This ſolution affords priſmatic cryſtals by evaporation, which melt in a gentle heat, emit the ſuperabundant acid, and ſhoot into elegant ramifications; they are very ſoluble in water, and in ardent ſpirits; redden turnſole; are ſublimed by a moderate heat; but decompoſed by a ſtronger, the ſaccharine acid firſt flying off, and afterwards the arſenical calx. Cobalt is attacked, either with or without heat, by this acid, which converts it into a faint roſe-coloured powder. The ſolution is yellow, and exhibits cryſtals more eaſily ſoluble, becauſe abounding in acid; but the roſe-coloured powder is ſcarcely ſoluble. The acid of ſugar ſeparates cobalt from all the known acids, and forms the roſe-coloured powder. Metallic zinc

efferveſces

effervefces ſtrongly with ſaccharine acid, and ſoon becomes covered with a white powder. This contains 75 parts of metal in the hundred, and is not ſoluble in water unleſs by exceſs of acid. The calx of zinc affords a ſimilar powder, and the like combination is obtained by adding acid of ſugar to the vitriolic, nitrous, or marine ſolutions of zinc. The regulus of antimony grows black by digeſtion with ſaccharine acid: but the calx and the glaſs are ſlowly diſſolved. The ſolution, which always contains an exceſs of acid, exhibits cryſtalline grains of difficult ſolubility in water. Manganeſe, in the form of the black calx, effervefces with this acid even in the cold; but the ſaturated ſolution depoſits a white powder nearly inſoluble in water, unleſs the acid predominate. This ſalt grows black in the fire, but recovers its whiteneſs upon the addition of more acid. The ſaccharine acid precipitates a white powder of the ſame nature, mixed with ſome cryſtalline grains, from the vitriolic, nitrous, or marine ſolutions of manganeſe *.

The theory of the ſaccharine acid is evidently of the ſame nature as that of every other combuſtible ſubſtance which acquires acid properties. In the original theory of chemiſtry, which was chiefly attended to by the illuſtrious Bergman (to whom we are indebted for moſt of the reſearches included in the preſent article), the nitrous acid is ſuppoſed to do little more than deprive the ſugar of a certain quantity of phlogiſton, which concealed the acid already exiſting in the ſugar, by neutralizing it, or maſking its properties. Others, however, though with leſs probability, have inferred, that the acid of ſugar conſiſts merely of the nitrous acid, altered by the phlogiſton or ſome other principle of the ſugar; an opinion which ſeems to be ſufficiently confuted by the diſcovery of the ſaccharine acid in the ſalt of ſorrel, wherein the previous exiſtence of nitrous acid cannot be proved, and which we may hope to ſee placed upon ſtill leſs equivocal ground, if this acid ſhould ever be produced by art in the way of actual combuſtion, or by the combination of vital air with the ſaccharine baſis, whether by a ſpeedy or ſlow proceſs.

We have elſewhere had frequent occaſion, however, to obſerve, that the facts will not admit of the mere ſuppoſition that dephlogiſtication is the cauſe of acidity, becauſe it is ſufficiently eſtabliſhed, that an abſorption of vital air takes place in this as well as other proceſſes analogous to combuſtion. Admitting, therefore, that ſugar (or ſome principle common to ſugar, gums, mucilages, hair, and the other bodies which afford this acid) is acidified by the abſorption of vital air, and waving the queſtion how far the diſengagement of an inflammable principle may take place, the chief object of enquiry will relate not to the nitrous acid that cauſes the acidification, but to the principle or baſis on which the peculiar properties of this acid depend. In this reſearch, as we have no direct or ſynthetical experiments, we muſt attend to the analyſes that take place by fire and by fermentation. In the deſtructive diſtillation of ſaccharine acid, we have ſcarcely any products but fixed air and heavy inflammable air, which laſt is with conſiderable probability taken to be a combination of light inflammable air and fixed air. Again it is found, that when the boiling with nitrous acid is continued too long, or the acid is ſtronger than it ought to be, a quantity of fixed air is extricated, and the ſaccharine acid is in a great meaſure converted into the acetous. It is likewiſe found, that when ſugar is treated with a weak nitrous acid, the produce is the acid of tartar, inſtead of that peculiarly diſtinguiſhed by the name of ſaccharine. When a ſolution of ſugar in water is expoſed to fermentation or ſpontaneous decompoſition, a conſiderable quantity of fixed air eſcapes, mucilage ſubſides, and the fluid contains ardent ſpirit, a ſubſtance eminently inflammable, but which affords ſaccha-

* Bergman de Acido Sacchari.

rine

rine acid, when properly treated, with the nitrous. During the ſubſequent ſtages of the fermentation, vital air is abſorbed, and the ardent ſpirit is no longer found, but is converted into vinegar. Whether the intermediate acids may be produced, or do exiſt, for any determinate ſpace of time in this proceſs, is not known.

From theſe circumſtances, it appears very probable, that an inflammable principle, exiſting in ſugar and many other bodies, is in the ſeveral proceſſes brought nearer to the ſtate of perfect acidity, accordingly as it abſorbs a greater quantity of vital air; that fixed air, vinegar, acid of ſugar, and acid of tartar, are ſubſtances in which this inflammable principle is more and more abundant, and are therefore convertible into each other, by dephlogiſtication, or the addition of vital air, though chemiſtry has not yet obtained the means of reverſing the proceſſes by the ſubtraction of the ſame principle. Sugar is probably converted into ardent ſpirit by ſuch a natural reverſing, in which fixed air or the moſt perfect vegetable acid flies off, and leaves a more inflammable ſubſtance, which afterwards attracts the vital parts of the atmoſphere, and becomes vinegar.

From this view of the ſubject, it will follow that the combuſtible ſubſtance is the baſis of fixed air: this is ſuppoſed, by the antiphlogiſtic philoſophers, to be charcoal, or a peculiar principle moſt eminently abundant in vegetable coal; but the Engliſh philoſophers, particularly Dr. Prieſtley, infer, that this principle is nothing elſe but inflammable air. The antiphlogiſtic philoſophers derive the inflammable air that appears in theſe and other ſimilar operations from the water, which they take to be decompoſed.

ACID OF SUGAR, EMPYREUMATIC. When ſugar is diſtilled without addition in a retort, a fluid acid liquor and oil paſs into the receiver. Mr. Schrickel * has purified and concentrated this acid liquor, and inveſtigated its properties. From ſixteen ounces of fine ſugar he obtained, by diſtillation, water, acid, and oil, amounting to eight ounces, four ſcruples, and a carbonaceous reſidue which weighed ſeven ounces and two ſcruples: ſo that ſix drachms were loſt in the operation. The firſt liquor which diſtilled was about ſix drachms in weight, ſcarcely acid, and was little elſe than water. The acid then paſſed in white vapours, and condenſed on the ſides of the receiver in ſtriæ, which ſeemed as if they were denſe and unctuous. This acid liquor had a pungent but pleaſant ſmell; in taſte it was ſharp, bitter, ſour, and empyreumatic; and in colour of a yellowiſh red. It affected the colour of ſyrup of violets but little, neither did it effervеſce much with mild alkali. The oil which paſſed in diſtillation was at firſt yellow, then became black and thick, and the whole quantity was about one ounce. This oil, by rectification, was rendered of a fine yellow colour, was ſpecifically heavier than the acid liquor, was bitter, ſharp, and dry to the taſte, and was ſoluble in ſpirit of wine.

The empyreumatic acid liquor was rendered, by repeated abſtractions from pure clay, perfectly clear, mild in ſmell, acid to the taſte, and capable of effervеſcing with mild alkalis. By means of froſt, Mr. Schrickel concentrated this acid, and combined it with different ſubſtances.

With vegetable fixed alkali he obtained a neutral ſalt, conſiſting of needle ſhaped cryſtals, which taſted like ſalt of Sylvius, were ſoluble with difficulty in cold water, but not at all in ſpirit of wine, remained dry in air, decrepitated and became white, but did not melt on hot coals.

The mineral alkali, ſaturated with this acid, gave, after a very ſhort evaporation,

* De ſalibus ſaccharinis vegetalibus & ſacchari albi vulgaris, analyſi, acidoque hujus ſpiritus. Gieſſæ, 1776. Quoted by Kier in his Dictionary, from which the preſent article is taken.

ſhining

ſhining yellow, ſix-ſided, ſharp-pointed cryſtals, which in taſte reſembled ſalt of Seignette; were eaſily ſoluble in water, but not in ſpirit of wine; remained dry in a dry air, but liquefied with a gentle heat, and in the fire were changed into a brown carbonaceous reſiduum.

With volatile alkali, this acid gave a ſharp ſaline liquor, which formed a ſaline maſs without any determinate form, or cryſtallization.

With calcareous earth, a ſimilar ſaline maſs was formed, which could be decompoſed either by an alkali, or by vitriolic acid.

Magneſia gave a gummy maſs, which, when dried, was like a hardened white of an egg.

Argillaceous or aluminous earth formed a gummy aſtringent ſaline maſs.

The concentrated acid diſſolved eaſily the calx of gold, and even gold-leaf. It exerted no action on ſilver, mercury, or their calces. Partly it calcined, and partly it tarniſhed lead. With minium it gave a yellow ſolution, which was not altered by nitrous acid, but gave a white precipitate on the addition of vitriolic and marine acids, or of alkalis, and a grey precipitate by means of infuſion of galls. This ſolution of minium ſhot into white, oblong cryſtals, of an aſtringent taſte. With filings of iron this acid gave a ſweetiſh, auſtere, and blood-red ſolution, in which green cryſtals ſhot. From a ſolution of theſe cryſtals, alkalis produced a green precipitate, the Pruſſian lixivium gave a black or dark blue precipitate, and marine acid a white precipitate. Vitriolic and nitrous acids occaſioned no precipitation. Copper is diſſolved by this diſtilled acid; and when the acid is very ſtrong, the metal is corroded into a browniſh green calx. The ſolution of copper does not cryſtallize, is green, forms with alkalis green precipitate, with infuſion of galls a yellowiſh green precipitate, but affords none by means of the mineral acids. Regulus of antimony gives a greeniſh ſolution with the diſtilled acid of ſugar, and is thence precipitated of a yellow colour by fixed alkali; by volatile alkali as a powder that is again ſoluble by the precipitant, by vitriolic and marine acids, and alſo by an infuſion of galls, as a white powder; but is not at all ſeparated from its ſolvent by nitrous acid. This acid partly diſſolves zinc, and forms a greeniſh ſolution, and partly calcines it to a greyiſh yellow powder. This ſolution gives a white precipitate on addition of infuſion of galls, alkalis, fixed, volatile, or phlogiſticated, or of vitriolic acid. Tin is partly diſſolved, but principally corroded by this acid into a greyiſh powder. The ſolution is precipitated by alkalis, and by an infuſion of galls, but not by any of the mineral acids.

ACID OF SUGAR OF MILK. The ſugar which is obtained by evaporation of whey differs little from the ſugar of vegetables. When treated with nitrous acid, in the manner of producing the ſaccharine acid, this laſt acid is not only afforded, but likewiſe another, which, becauſe firſt diſcovered in this peculiar ſugar, was denominated the acid of ſugar of milk*.

Twelve ounces of diluted nitrous acid being poured upon four ounces of finely powdered ſugar of milk, in a glaſs retort on a ſand bath, with a receiver annexed, the mixture became gradually hot, and at length effervеſced violently, and continued to do ſo for a conſiderable time after the retort was taken from the fire. It is neceſſary therefore, in this experiment, to uſe a large retort, and not to lute the receiver too tight. After the effervеſcence had in ſome meaſure ſubſided, the retort was again placed on the ſand bath, and the nitrous acid diſtilled off till the maſs had acquired a yellowiſh colour. This yellow fluid exhibited no cryſtals. Eight ounces

* By Scheele. See Eſſays, Eng. tranſlation, p. 278.

more of the ſame nitrous acid were therefore added, and the diſtillation again repeated, till the yellow colour of the fluid diſappeared. The fluid became inſpiſſated by cooling; for which reaſon it was re-diſſolved in eight ounces of water, and filtered. Seven drams and a half of a white powder remained on the filter, and the clear ſolution afforded cryſtals of ſaccharine acid. The mother water was again treated ſeveral times with nitrous acid, by which means the whole was at length changed into ſaccharine acid.

The white powder that remained on the filter was found to be combuſtible like oil, in a red hot crucible, without leaving any mark of aſhes behind. It was ſoluble in ſixty times its weight of boiling water; and one fourth part ſeparated by cooling in the form of very ſmall cryſtals. The remaining maſs being then collected by evaporating the greateſt part of the water, left behind a ſmall portion of the acid of ſugar, from which it had not been ſo exactly deprived by edulcoration on the filter. From theſe circumſtances it appeared, that the white matter was a ſalt, and, upon examination, it proved to be an acid poſſeſſing the following properties:

This acid, or the acid of ſugar of milk, forms with the ſoluble earths ſalts inſoluble in water. It diſengages fixed air from the mild alkalis. With the vegetable alkali it forms a ſalt ſoluble in eight times its weight of boiling water, but ſeparable for the moſt part by cooling. With the mineral alkali it affords a ſalt that requires only five parts of boiling water for its ſolution. Both theſe ſalts are perfectly neutral. When ſaturated with volatile alkali, it forms a ſalt which, after being gently dried, has a ſouriſh taſte. It does not perceptibly act on the metals, perhaps becauſe ſo little concentrated; but it forms with their calces ſalts of very difficult ſolubility, which therefore fall down.

Gum tragacanth and ſome other vegetable mucilages alſo afford this acid.

ACID OF TARTAR. Tartar was a long time conſidered as one of the products of the vinous fermentation, becauſe it is obtained, for the purpoſes of commerce, from wine, during the inſenſible fermentation of which liquid it is gradually depoſited on the ſides of the caſks. But it exiſts ready formed in muſt, in verjuice, in tamarinds, ſtrawberries, peaches, gooſeberries, apricots, raſpberries, mulberries, apples, pears, barberries, and pomegranates, from all which it may be extracted by expreſſing their juice, and expoſing it to congelation, which alters and deſtroys the mucilage, and converts great part of the aqueous fluid into ice, without producing that conſiderable change in the remaining fluid which evaporation by heat would not fail to do. As ſoon as the fluids have loſt three fourths or more of their weight, by taking away the ice as it is formed, a ſaline depoſition, loaded with the colouring and extractive matter of the fruit, falls to the bottom of the veſſels; and this, after purification by repeated waſhings in ſmall quantities of cold water and of ardent ſpirit, becomes at length purified, and is found, on examination, to be cream of tartar: for it affords the ſame combinations with alkaline ſalts, has the ſame habitudes in the fire, and, in a word, does not differ from that ſubſtance. In this courſe of experiments fixed and conſtant reſults are not to be expected, unleſs a conſiderable quantity of each fruit be uſed: for in moſt of them the ſaline part is ſo ſmall in quantity, and ſo enveloped in mucilage, that it would ſcarcely be rendered perceptible if only an ordinary quantity were uſed, and more eſpecially if the fruit were perfectly ripe *.

Crude tartar is ſeldom uſed in medicine, or philoſophical chemiſtry; the refined tartar is known by the name of cream, or cryſtals of tartar. The purification of this

* De Laſſone and Cornette, in the Memoirs of the Royal Academy of Sciences at Paris, for the year 1786, p. 606.

ſalt is effected by diſſolving it in boiling water, filtering, and ſuffering it to cryſtallize by cooling; the cryſtals are again boiled, together with an argillaceous earth, to deprive them of their impurities, which are carefully ſcummed off; or elſe with whites of eggs, which anſwers the ſame purpoſe. When no more ſcum ariſes, a ſaline pellicle is formed at the top of the liquor, at the ſame time that the cryſtallization goes forward at the bottom. This ſalt, after the earth is waſhed off with cold water, is ſold under the name of cream, and cryſtals of tartar. The cream of tartar conſiſts of the minute cryſtals which are formed at the top of the liquor, and the cryſtals of tartar are formed at the bottom.

The taſte of this purified ſalt is leſs vinous than that of the crude tartar. When expoſed to heat it boils up, emits an empyreumatic ſmell, and becomes black and coaly: a ſtronger heat, in an open fire, entirely diſſipates its acid part, and leaves the vegetable alkali in a mild ſtate, or combined with fixed air. Its volatile products, by a gradual fire, are water, an acid, and an empyreumatic oil, which is followed by ſome volatile alkali, and a large quantity of fixed air. Cryſtals of tartar are ſoluble in twenty-eight parts of boiling water; three fourths of the ſalt are depoſited in cooling. If the ſolution of this ſalt be left expoſed to the air, it is very ſlowly decompoſed; mucilage is depoſited, the acid diſappears, and after eighteen months the liquid is found to contain the vegetable alkali, amounting to nearly one fourth of the weight of the tartar. This quantity of alkali being nearly the ſame as is afforded by the incineration of tartar, is a proof that the vegetable alkali is not a product of fire, as was formerly ſuppoſed.

Cream of tartar conſiſts of a peculiar acid, or the acid of tartar united with a leſs quantity of alkali than is ſufficient to ſaturate it, or deprive it of acid properties. Saturation being diſtinguiſhed by the mutual counterpoiſe or moſt perfect re-action of the properties of two ſubſtances which enter into combination, is obſerved in general to take place when the proportions of the principles are ſuch as tend moſt ſtrongly to form a ſeparate combination in the ſolid ſtate. The cream of tartar and a few other neutral ſalts afford curious exceptions to this general rule. Of the acid and the alkali, both of which are ſoluble in ſmall quantities of water, and therefore not eaſily ſeparable from that fluid, a compound is formed, which is ſo ſparingly ſoluble as to require more than eighty times its weight of cold water to ſuſpend it. This compound, or cream of tartar, is rendered more ſoluble by increaſing either the acid or the alkali beyond the due proportion; and the moſt remarkable circumſtance is, that this happens, as we have already remarked, not at the point of ſaturation, but at that in which the acid ſo conſiderably abounds.

If to twenty ounces of purified tartar, diſſolved in four pounds of boiling water, the pure cryſtallized mineral alkali be added, until the ſaturation be complete, as may be judged by any additional quantity producing no effervescence, the alkali laſt added will combine with the ſuperfluous acid of the tartar, and form the neutral combination called the ſalt of Seignette, or Rochelle ſalt; at the ſame time that the reſidue of the tartar will become converted into ſoluble tartar. By evaporating the liquor nearly to the conſiſtence of ſyrup, the Rochelle ſalt is obtained in beautiful regular prifms, of ſix or eight ſides, which effloreſce in the air, and are decompoſed by heat in the ſame manner as ſoluble tartar.

By the ſame treatment with volatile alkali, an ammoniacal tartareous ſalt is formed, which affords cryſtals that effloreſce in the air.

If the mineral acids be added to tartar, they combine with its alkali, and form the ſame ſalts as they would have produced by direct union with the vegetable alkali.

Tartar has long been an object of attention with chemiſts, and it is uſed as an acid in many of the arts. This ſalt appears to be capable of uniting without decompoſition, and forming triple ſalts with moſt of the metals.

The pure acid of tartar may be obtained by ſaturating three parts of cream of tartar with chalk or lime; the former of which combines with the ſuperfluous acid, and the latter ſeizes the whole. The calcareous tartar, which on account of its inſolubility remains at the bottom, is then to be well waſhed, and digeſted with about one part of vitriolic acid, together with a ſufficient quantity of water. In this manner the acid of tartar is diſengaged. The ſelenite, formed by the combination of the vitriolic acid and the lime, will be ſeparated and fall down by evaporating the water; and the acid which remains may be cryſtallized by further evaporation and cooling.

Or, more ſimply, one pound of cream of tartar may be boiled in five or ſix pounds of water, and a quarter of a pound of clear and colourleſs denſe vitriolic acid may be added by little and little. When a complete ſolution is obtained, the fluid will then contain diſengaged acid of tartar, together with vitriolated tartar, or the neutral ſalt, formed by the union of the vitriolic acid with the vegetable alkali. The vitriolated tartar, being a ſalt of ſparing ſolubility, will be precipitated by continuing the boiling. When the liquor is evaporated to one half, it is to be filtered; and if, upon further evaporation, any thing more is precipitated, it muſt be filtered again. The clear liquor being then reduced to the conſiſtence of a ſyrup, and ſet aſide in a temperate or rather warm place, will afford fine cryſtals of tartareous acid, equal in weight to half the cream of tartar employed. If too ſmall a quantity of vitriolic acid has been uſed, part of the cream of tartar will not be decompoſed, but will ſeparate from the liquor along with the vitriolated tartar. It is better therefore to uſe too little, rather than too much.

The cryſtallized tartareous acid melts, fumes, becomes black, and burns, by the contact of ignited bodies. By diſtillation it affords an acid phlegm, a ſmall quantity of oil, and much fixed air, together with inflammable air, leaving behind a coaly reſidue, which contains neither acid nor alkali.

The cryſtals of tartareous acid do not change by expoſure to air; they are much more ſoluble in water than cream of tartar itſelf. This acid diſſolves clay, and forms a ſalt which, by evaporation, aſſumes a clear gummy conſiſtence, and does not deliqueſce in the air. The ſame appearance is exhibited with magneſia: with lime it forms a ſalt which is ſcarcely at all ſoluble; a due proportion of vegetable alkali converts tartareous acid into cream of tartar, which falls down if the water of ſolution be not ſufficiently abundant, but is diſſolved again if more alkali be added, ſo as to convert it into ſoluble tartar. Theſe ſynthetical operations ſhew that the tartareous acid is not altered by the proceſs of extracting it from cream of tartar.

With mineral alkali it forms the Rochelle ſalt, and with volatile alkali it forms a cryſtallizable ſalt. In this laſt combination, which has a neutral cooling taſte reſembling that of nitre, there is a term at which cryſtals of ſparing ſolubility, like thoſe of cream of tartar, are formed; for which reaſon it is neceſſary, in preparing the neutral ſalt, to add a ſufficient quantity of alkali at once to ſaturate the acid, becauſe in this caſe of inſoluble cryſtals likewiſe, the proportion of acid is conſiderably more than is required for the due ſaturation.

Gold, in the metallic ſtate, is not acted upon by the tartareous acid, though it unites with the precipitate afforded by adding an alkali to a ſolution of that metal. Platina likewiſe is ſaid to be ſoluble in cream of tartar after it has been precipitated by alkali, though not in its metallic ſtate. The precipitate of ſilver, from nitrous acid

by an alkali, unites with the tartareous acid into a ſaline maſs, which turns black by expoſure to light, and from which the ſilver may be ſeparated, in its metallic ſtate, by quickſilver, as well as by other metals. Mercury is changed into a kind of ethiops or black powder by the tartareous acid; which alſo acts upon mercurial calces, and converts them into yellow powders. A ſolution of tartareous acid being added to the nitrous ſolution of mercury, a precipitate of tartarized mercury falls down: but this acid does not cauſe any precipitate in a ſolution of corroſive ſublimate, unleſs an alkali be at the ſame time added to engage the marine acid. Copper, in its metallic ſtate, is ſcarcely attacked by the acid of tartar; but the calces of this metal are conſiderably acted upon. It precipitates ſolutions of copper in the vitriolic and marine acids, the tartareous acid uniting with the calx of the metal in the form of blue cryſtals. This blue ſalt forms the better kind of the pigment called Brunſwick green. Lead is precipitated by the acid of tartar from its ſolution in the nitrous, marine, or acetous acids. The precipitate, which is a tartarized lead, is ſoluble in nitrous acid, and decompoſable by the vitriolic. It is difficultly ſoluble in water; whereas the ſalt formed by uniting calx of lead with cream of tartar is ſaid to be eaſily ſoluble. The acid of tartar deprives minium of its colour. Iron is attacked by this acid with a ſlow efferveſcence, during which the metal is precipitated in the form of a granulated grey powder; and when a ſolution of this metal in water is mixed with a ſolution of martial vitriol, and the mixture evaporated to half its quantity, ſcaly cryſtals of a ferruginous taſte will be formed. Tartareous acid has no action upon tin, and its action upon the calces of tin has not yet been aſcertained. Tartar itſelf is known to poſſeſs ſome diſſolving power on tin, and is capable of uniting with its calx into a cryſtallizable and ſoluble ſalt. When this acid is added to the nitrous ſolution of biſmuth, a tartarized biſmuth ſoon appears in the form of cryſtalline grains. The action of the acid of tartar in its pure ſtate upon nickel, arſenic, and regulus of cobalt, has not yet been aſcertained. It diſſolves zinc with great facility, and affords a difficultly ſoluble ſalt; whereas the tartar itſelf forms a ſoluble and even deliqueſcent ſalt. Regulus of antimony ſuffers no change from the action of this acid, but it combines with the calces *.

The acid of tartar is convertible into the ſaccharine acid, by diſtillation with ſtrong nitrous acid. Digeſtion with water and ardent ſpirit converts it into vinegar.

ACID OF TIN. This metal is converted into an acid by treatment with the acid of nitre. *See* TIN.

ACID OF TUNGSTEN, *or* WOLFRAM. The mineral called tungſten, or heavy ſtone, was firſt analyzed by Scheele and Bergman, and afterwards more completely examined by Meſſrs. De Luyarts. As the tungſten conſiſts of a metallic acid united with lime, neither of which ſubſtances are ſoluble in one and the ſame menſtruum in any conſiderable quantity, the analyſis of this ſtone in the humid way has been a matter of conſiderable difficulty: for when an acid is added to diſſolve the lime, it unites with ſuch particles as lie near the ſurface of the tungſten, and cannot afterwards proceed in its action, becauſe its further progreſs is prevented by the acid of tungſten which envelopes the remaining lime that occupies the interior part of the ſtone. And again, when an alkali is added to diſſolve the acid of tungſten, its action is likewiſe merely ſuperficial, becauſe it meets with a ſimilar impediment from particles of lime which defend the acid in the interior parts of the ſtone from its progreſſive action.

The ingenious chemiſts, who have buſied themſelves in this examination, could

* Kier's Dictionary, page 173.

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recur therefore to no other humid proceſs than that of boiling, firſt an acid, and afterwards an alkali, upon the pulverized ſtone, and repeating theſe proceſſes alternately until the whole was diſſolved. The tungſten is not altered by the action of boiling water. Two parts of concentrated vitriolic acid being diſtilled from one part of finely powdered tungſten, the acid came over unchanged, and the reſiduum, which was of a bluiſh colour, afforded ſome ſelenite by boiling in diſtilled water. Three parts of nitrous acid being poured on one part of finely powdered tungſten produced no efferveſcence; but, upon the mixture being put into ſtrong digeſtion, the powder ſoon aſſumed a lemon colour. The acid was then decanted off, and the yellow powder, after edulcoration, was heated with two parts of cauſtic volatile alkali, which ſoon deſtroyed the yellow colour of the powder, and rendered it white. This menſtruum was likewiſe decanted off, and the powder again edulcorated. In this manner Scheele proceeded, by digeſting the ſame portion of tungſten, firſt in the nitrous acid, and then in the volatile alkali, till at length the greateſt part was diſſolved. The remainder was little more than a thirtieth of the whole, and ſeemed to be ſiliceous. Marine acid produces the ſame effect upon tungſten, but the ſtone becomes more ſtrongly yellow.

All the acid ſolutions being mixed together, afforded a ſmall portion of iron when the Pruſſian alkali was added. Volatile alkali afforded no precipitate; but, upon the addition of mild vegetable alkali, a mild calcareous earth fell down, which weighed a little more than half the weight of the tungſten. The ſolutions made by the volatile alkali were alſo mixed together, and nitrous acid was gradually added. A precipitate fell down of a white colour, which was waſhed with cold water and dried. This precipitate proved to be of an acid nature, having a ſour taſte, affording a red colour to tincture of litmus, and being ſoluble in near twenty parts of boiling water.

The products afforded by tungſten in this way, conſiſting of calcareous earth and the white acid powder, it was natural to infer that theſe were the component parts of the ſtone; and it remained only to confirm this operation by ſynthetically producing tungſten from the union of its principles. One part of the acid ſolution was therefore added to ſix parts of clear lime-water, which immediately became a little turbid; but as, after an interval of ſome hours, nothing had ſunk to the bottom, the mixture was made to boil, and immediately afforded an heavy white powder, which had the ſame habitudes with the vitriolic and nitrous acids, and with the blow-pipe, as the tungſten itſelf, and conſequently was that ſubſtance.

Fire does not produce any perceptible change in tungſten, nor does the glaſs of borax produce any ſenſible effect upon it, according to the experiments of Scheele, which perhaps were made in a crucible. Bergman found that it decrepitated before the blow-pipe, but did not melt, and was ſoluble in borax without efferveſcence, and almoſt without colour, except when the globule was overloaded with tungſten, in which caſe it becomes brown or white in cooling, and loſes its tranſparency. Microcoſmic ſalt forms with tungſten a glaſs of a ſea-green or pure blue colour. The green colour, as obſerved by Scheele, diſappears by the addition of nitre, but returns when the blue part of the flame is driven on the globule; a circumſtance which ſhews that the colour diſappears by a more perfect calcination of the metallic acid of the tungſten, and is reſtored by a degree of reduction in the interior part of the flame, as is likewiſe obſerved with manganeſe; *ſee* MANGANESE. For the dry analyſis of tungſten, one part of the ſtone, rubbed to a fine powder in a glaſs mortar, was mixed with four parts of alkali of tartar, and placed in the fire in an iron crucible. The mixture, when melted, was poured out upon an iron plate, and diſſolved

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in twelve parts of boiling water. After ſtanding ſome hours, this lixivium was decanted off from a portion of white powder which had ſubſided to the bottom. Acid of nitre diſſolved a great part of this powder previouſly edulcorated. The undiſſolved part, or tungſten which had eſcaped the action of the alkali during the fuſion, being again dried, mixed with four parts of alkali of tartar, and brought into fuſion as before, left a powder undiſſolved upon the addition of water, the whole of which was ſoluble in nitrous acid, excepting a very ſmall portion of a grey powder. In this way the component parts of the tungſten afforded an alkaline and an acid ſolution. To the alkaline ſolution nitrous acid was added to ſaturation, upon which a white powder fell down, which having the property of regenerating tungſten by the addition of lime, was concluded to be the acid of tungſten: and the nitrous acid ſolution being likewiſe neutralized by adding the mild vegetable alkali, afforded a white precipitate, which was dried, and proved to be mild calcareous earth. Hence it follows that the dry analyſis afforded the ſame products as that in the humid way.

To the experiments of Scheele, which had likewiſe been made by Bergman, others were added in confirmation by this laſt chemiſt, who ſuſpected the acid to be of a metallic nature, for reaſons which, though they do honour to his ſagacity, need not be here recited, becauſe his ſuſpicions have been ſince eſtabliſhed by the more perfect analyſis of his pupils, the Meſſrs. Luyarts. Theſe gentlemen undertook to examine the mineral called wolfram, concerning which we before poſſeſſed little more than conjectures. The wolfram they examined is of a browniſh black colour, found in ſcattered maſſes, cryſtallized into ſix-ſided flat priſms, terminating in four-ſided oblique pyramids. In its fracture it ſhines with a luſtre almoſt metallic. Its texture is irregularly laminated, and very ſeldom ſtriated. It is always opake, yields a dark reddiſh grey powder when ſcraped, is ſoft, and has a ſpecific gravity of 6.835. This wolfram was obtained from the tin mines of Zinnwald, on the frontiers of Saxony and Bohemia.

The blow-pipe has no other effect upon it than merely to round its angles. Microcoſmic ſalt unites with it with efferveſcence, and forms a glaſs of a pale red in the exterior flame, and much darker in the interior. With borax it likewiſe efferveſces, and forms in the interior flame a glaſs of a greeniſh yellow, which in the exterior flame turns reddiſh. The wolfram, kept for an hour in a crucible ſtrongly heated, became ſemi-vitrified, ſpungy, of a browniſh colour, and yielded to the magnet. Equal parts of nitre and wolfram detonated weakly in a red hot crucible, and emitted nitrous vapours. The combination being afterwards mixed with water, diſſolved in part, and the clean ſolution afforded a white precipitate upon the addition of a few drops of acid. This precipitate was the ſame ſubſtance as the tungſten acid of Scheele obtained in the dry way.

Two parts of pulverized wolfram melted without difficulty with four of vegetable alkali; about one third of the wolfram was not diſſolved by the alkali, and this third part proved to be iron and manganeſe. The reſt was diſſolved in water, and, upon the gradual addition of nitrous acid, afforded a white precipitate, of the ſame nature as the acid ſubſtance obtained, in the dry way, from tungſten by Scheele and Bergman.

This white ſaline ſubſtance, which thoſe chemiſts inferred to be a ſimple acid, was proved by the Meſſrs. Luyarts to be a compound, conſiſting of the calx or true acid of wolfram combined with a portion both of the alkali and of the precipitating acid. Its general properties they found to be as follow:

With the blow-pipe it melts alone; and, when put to calcine in a little pot or teſt, it

it emits a ſmell of nitrous acid, and turns yellow; but, on cooling, it remains white, inſipid, and inſoluble. This reſiduum alſo melts in the blow-pipe. When either vitriolic, nitrous, or marine acid, is poured on this ſalt, they produce a yellow colour, and in the filtrated ſolution is found a neutral ſalt with baſe of fixed alkali correſponding with the acid employed. If this operation be performed with vitriolic acid in a retort, a portion of nitrous acid paſſes into the receiver, while the vitriolic acid forms vitriolated tartar. Whence it is clearly proved that the compound itſelf contains nitrous acid and vegetable alkali.

When regenerated tungſten was formed by adding lime-water to this white matter, the acid and alkali were found in the ſupernatant fluid.

Meſſrs. Luyarts analyzed wolfram likewiſe, in the humid way, by repeated alternate ebullitions of the powder with marine acid, edulcoration with water, and affuſions of cauſtic volatile alkali. In this way the whole of the wolfram was at laſt diſſolved, except about one fiftieth part, which was partly quartz, and partly ſeemed to be calx of tin. The acid ſolutions being examined, were found to contain iron and manganeſe, equal to ſomewhat more than one third of the whole; and the alkaline ſolutions, by evaporation, afforded the yellow calx of tungſten. They found likewiſe, by examining the precipitate of Scheele, from the volatile alkaline ſolution, by the addition of nitrous acid, that it contained volatile alkali and nitrous acid, as well as the yellow calx, inſtead of being a pure acid, as that chemiſt had concluded: for when tungſten is produced by the addition of lime-water to this precipitate, a ſmell of volatile alkali is emitted, and the ſupernatant fluid contains calcareous nitre.

The ſubſtance which therefore unites with lime in forming tungſten, and with manganeſe and iron in wolfram, is the yellow calx or acid which the Meſſrs. De Luyarts obtained from the alkaline ſolution, in the dry way, by precipitation with nitrous acid; repeated ebullition of nitrous acid on the precipitate to deprive it of all alkali; and laſtly, calcination to expel the adhering nitrous acid: and, in the humid way, they obtained it by adding nitrous acid to the volatile alkaline ſolution, and afterwards depriving the precipitate of its adhering acid and volatile alkali, by calcining it likewiſe under a muffle. This is the true acid of wolfram, if indeed it may be termed an acid.

It poſſeſſes the following properties: 1. It is entirely inſipid, and has a ſpecific gravity of 6.12. 2. Before the blow-pipe it continues yellow in the exterior flame, although it be placed on charcoal; but in the interior flame it grows black and ſwells, but does not melt. It may be here obſerved, that the heating by the exterior flame may be conſidered as equivalent to an operation with acceſs of air; and the heating by the interior flame anſwers to the heating in a cloſed veſſel, becauſe the ſurrounding flame prevents the acceſs of air. Upon charcoal, therefore, the former calcines, while the latter reduces metallic bodies. 3. With microcoſmic ſalt it unites with effervеſcence, and forms in the interior flame a tranſparent glaſs of a blue colour, more or leſs intenſe according to the proportion, but without any mixture of red. In the exterior flame the colour vaniſhes entirely, but returns again in the interior. Theſe effects doubtleſs ariſe from the greater degree of calcination which the yellow matter ſuffers in the exterior flame, and of reduction in the interior flame. They cannot, however, be very often repeated, becauſe, as Meſſrs. De Luyarts obſerve, the alkali of the aſhes of the charcoal combines with the glaſs, and totally deſtroys the colour, as is proved by the addition of a ſmall particle of alkali to the coloured glaſs in fuſion. 4. With borax it forms a browniſh yellow tranſparent glaſs, which keeps its colour in both flames. 5. This acid or yellow matter does not diſſolve

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in water, but by trituration it forms an emulſion which paſſes through filters without becoming clear, and does not become entirely ſo in the courſe of three months. 6. The vitriolic, nitrous, and marine acids, have no action upon it, and do not form any emulſion with it by trituration. The acetous acid gives it a blue colour without diſſolving it. 7. Cauſtic vegetable alkali completely diſſolves it, both in the humid and dry way; but the produce always has an exceſs of alkali. When a few drops of nitrous acid are added to the alkaline ſolution, a white precipitate is inſtantly formed, which is re-diſſolved by agitation as long as the alkali continues in exceſs, the liquor becoming more and more bitter; and when more acid is poured on than is neceſſary to ſaturate the exceſs, the precipitate which is formed is not re-diſſolved. This white ſalt contains the yellow matter in combination with nitrous acid and vegetable alkali, and is in fact the ſubſtance which Scheele obtained from tungſten by fuſion with vegetable alkali, and precipitation by nitrous acid, and diſtinguiſhed by the name of acid of tungſten. 8. Volatile alkali likewiſe diſſolves the yellow matter completely, but always with an exceſs of alkali. This ſolution affords cryſtals by evaporation, loſes its alkali partly by boiling, and completely by calcination; affords a white precipitate by the addition of nitrous acid, which is perfectly ſimilar to the tungſten acid of Scheele, when obtained by the medium of volatile alkali, and is completely decompoſed by heat. 9. And laſtly, this yellow matter may be revived into a metal by a ſtrong heat with charcoal, in a covered crucible, and gains weight by calcination like other metallic bodies. *See* WOLFRAM.

The yellow colour, produced by the action of nitrous or marine acid, affords an eaſy teſt of the preſence of the wolfram calx or acid in minerals.

ACIDS, VEGETABLE. *See* VEGETABLE KINGDOM.

ACID, VITRIOLIC, *or* OIL OF VITRIOL OF COMMERCE. When ſulphur is heated in an open veſſel, it melts, and ſoon afterwards emits a bluiſh flame, viſible in the dark, but which, in open day-light, has the appearance of a white fume. This flame has a ſuffocating ſmell, and has ſo little heat that it will not ſet fire to flax, and may even be ſuffered to play againſt the palm of the hand without any conſiderable inconvenience. In this way the ſulphur may be entirely conſumed. If the heat be ſtill augmented, the ſulphur boils, and ſuddenly burſts into a much more luminous flame, the ſame ſuffocating vapour ſtill continuing to be emitted.

The ſuffocating vapour of ſulphur is imbibed by water, with which it forms the fluid called volatile vitriolic acid. If this fluid be expoſed for a time to the air, it loſes the ſulphureous ſmell it had at firſt, and the acid becomes more fixed. It is then the fluid which was formerly called the ſpirit of vitriol. Much of the water may be driven off by heat, and the denſe acid which remains is the vitriolic acid, commonly called oil of vitriol; a name which was probably given to it from the little noiſe it makes when poured out, and the unctuous feel it has when rubbed between the fingers, produced by its corroding and deſtroying the ſkin, with which it forms a ſoapy compound.

The ſtone or mineral called martial pyrites, which conſiſts for the moſt part of ſulphur and iron, is found to be converted into the ſalt called vitriol of iron, by expoſure to air and moiſture. In this natural proceſs the pyrites breaks and falls in pieces; and if the change takes place rapidly, a conſiderable increaſe of temperature follows, which is ſometimes ſufficient to ſet the maſs on fire. By conducting this operation in an accurate way, it is found that vital air is abſorbed. The vitriol is obtained by ſolution in water, and ſubſequent evaporation; by which the cryſtals of the ſalt are ſeparated from the earthy impurities which were not ſuſpended in the water.

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The vitriolic acid was formerly obtained in this country by diſtillation from vitriol of iron, as it ſtill is in many parts abroad. The common green vitriol is made uſe of for this purpoſe, as it is to be met with at a low price, and the acid is moſt eaſily to be extracted from it. With reſpect to the operation itſelf, the following particulars ſhould be attended to: Firſt, the vitriol muſt be calcined in an iron or earthen veſſel, till it appears of a yellowiſh red colour; by this operation it will loſe half its weight. This is done in order to deprive it of the greateſt part of the water which it has attracted into its cryſtals during the cryſtallization, and which would otherwiſe in the enſuing diſtillation greatly weaken the acid. As ſoon as the calcination is finiſhed, the vitriol is to be put immediately, while it is warm, into a coated earthen retort, which is to be filled two thirds with it, ſo that the ingredients may have ſufficient room upon being diſtended by the heat, and thus the burſting of the retort be prevented. It will be moſt adviſable to have the retort immediately encloſed in brick-work in a reverberatory furnace, and to ſtop up the neck of it till the diſtillation begins, in order to prevent the materials from attracting freſh humidity from the air. At the beginning of the diſtillation the retort muſt be opened, and a moderate fire is to be applied to it, in order to expel from the vitriol all that part of the phlegm which does not taſte ſtrongly of the acid, and which may be received in an open veſſel placed under the retort. But as ſoon as there appear any acid drops, a receiver is to be added, into which has been previouſly poured a quantity of the acidulous fluid which has come over, in the proportion of half a pound of it to twelve pounds of the calcined vitriol, when the receiver is to be ſecured with a proper luting. The fire is now to be raiſed by little and little to the moſt intenſe degree of heat, and the receiver carefully covered with wet cloths, and (in winter time) with ſnow or ice, as the acid riſes in the form of a thick white vapour, which towards the end of the operation becomes hot, and heats the receiver to a great degree. The fire muſt be continued at this high pitch for ſeveral days, till no vapour iſſues from the retort, nor any drops are ſeen trickling down its ſides. In the caſe of a great quantity of vitriol being diſtilled, M. Bernhard has obſerved it to continue emitting vapours in this manner for the ſpace of ten days. When the veſſels are quite cold, the receiver muſt be opened carefully, ſo that none of the luting may fall into it. After which the fluid contained in it is to be poured into a bottle, and the air carefully excluded. The fluid that is thus obtained, is the ordinary oil of vitriol, of which Bernhard got ſixty-four pounds from ſix hundred weight of vitriol; and on the other hand, when no water had been previouſly poured into the receiver, fifty-two pounds only of a dry concrete acid.

The vitriolic acid made in theſe kingdoms is produced by the combuſtion of ſulphur. There are three conditions requiſite in this operation. Vital air muſt be preſent, to maintain the combuſtion; the veſſel muſt be cloſe, to prevent the eſcape of the volatile matter which riſes; and water muſt be preſent to imbibe it. For theſe purpoſes, a mixture of eight parts of ſulphur with one of nitre is placed in a proper veſſel, encloſed within a chamber of conſiderable ſize, lined on all ſides with lead, and covered at bottom with a ſhallow ſtratum of water. The mixture being ſet on fire, and ſhut up, will burn for a conſiderable time, by virtue of the ſupply of vital air which nitre gives out when heated; and the water imbibing the ſulphureous vapours, becomes gradually more and more acid, after repeated combuſtions, and the acid is afterwards concentrated by diſtillation.

The vitriolic acid is conſiderably denſer than any other acid or tranſparent fluid, and in general its affinities are ſtronger. It ſtrongly attracts water, which it takes from the atmoſphere very rapidly, and in large quantities, if ſuffered to remain in an

open veſſel. If it be mixed with water it produces an inſtantaneous heat equal to that of ebullition.

Pure vitriolic acid is colourleſs, and emits no fumes. When it is heated it becomes more and more concentrated by the loſs of a portion of water, which riſes before the acid itſelf. No permanently elaſtic fluid or air is obtained from the vitriolic acid by mere heat in the common method, but the addition of any combuſtible ſubſtance cauſes it to become of a dark or brown colour, more eſpecially if the ſubſtance be either an animal or vegetable product; at the ſame time that vitriolic acid air is emitted, which is of the ſame nature as the fumes of burning ſulphur. For the production of this air, it is neceſſary that but a ſmall quantity of oil, or any other very combuſtible ſubſtance, ſhould be added at a time; becauſe otherwiſe the acid would be thrown out of the veſſel by the violence of the ebullition. The moſt elegant method of procuring vitriolic air conſiſts in boiling a ſmall quantity of mercury in the concentrated acid. Several of the other metals produce the ſame effect. With iron the greateſt part of the elaſtic product conſiſts of vitriolic air, and the reſt, which is about one fifth, is inflammable. This laſt product is leſs in quantity, the more concentrated the acid. Zinc affords vitriolic air, together with a quantity of inflammable air, amounting to near two thirds of the product. The whole produce with copper is vitriolic acid air. Silver likewiſe affords this elaſtic product alone. Lead yields but a ſmall quantity of vitriolic air, which has nothing inflammable in it. Neither gold nor platina afforded any air; the acid acting upon neither of them. The gold however rendered the acid of a yellowiſh colour, probably in conſequence of a minute quantity of impurity *.

Vitriolic acid air is imbibed by water, in the quantity of about ninety times the bulk of the water; and it is remarkable that it is not expelled by freezing, like all other kinds of air. The ice of this water ſinks to the bottom, a circumſtance for which Dr. Prieſtley does not offer to account, but which ſeems to explain in ſome meaſure the difficulty attending the expanſion of common water by freezing, though the general operation of cold diminiſhes the bulks of bodies: for it ſeems reaſonable to infer, that the ice of water would in all other caſes, as well as the preſent, be heavier than water in the fluid ſtate, if it were not for its aerial contents, which aſſume the elaſtic form.

Vitriolic acid air is perfectly tranſparent, and, when confined by quickſilver, its dimenſions are not liable to any variation, excepting by heat and cold, juſt like common air, provided there be no moiſture in the receiving veſſel, or in the mercury. It inſtantly extinguiſhes flame, and deſtroys animal life. According to Mr. Kirwan's experiments, it is more than twice as heavy as atmoſpheric air, being the heavieſt of all the elaſtic fluids. From this cauſe it extinguiſhes a candle for many times ſucceſſively, by dipping the ſame into an open jar in which it has ſtood a full hour with its mouth expoſed to the common air. Cold, or a diminution of temperature, does not occaſion any greater diminution of its bulk than common air is ſubject to in the ſame circumſtances.

When vitriolic acid air is mixed with alkaline air, a beautiful white cloud is formed by their combination, while both airs gradually aſſume the ſolid ſtate, ſo that the mercury riſes almoſt to the top of the veſſel. The white cloud muſt of courſe conſiſt of the ſalt called vitriolic ammoniac. If the acid air be poured to the alkaline air, the cloud is formed at the bottom, and gradually riſes to the top; but if the alkaline air be poured in laſt of the two, the cloud immediately riſes to the top.

* Prieſtley on Air, 1790, ii. 304.

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Theſe conſequences naturally reſult from the alkaline air being the lighteſt of the two.

There was frequently an appearance of ſulphur produced upon the mixture of alkaline air with vitriolic acid air; for the inſide of the tube would be covered with a perfectly yellow matter: but this colour goes off in time, and nothing but a white ſaline ſubſtance remains. No remarkable appearance is produced upon the mixture of vitriolic acid air with other airs; but common air is injured by ſtanding in contact with this elaſtic fluid. It is moſt probable that the vitriolic acid air became converted into common vitriolic acid by attracting vital air from the air of the atmoſphere, which muſt conſequently have been left in a leſs reſpirable ſtate than before.

This acid air was not found by Dr. Prieſtley to be capable of diſlodging the nitrous or marine acids from any of their baſes which he tried; a circumſtance doubtleſs depending on the phlogiſtication or want of vital air neceſſary to convert it into vitriolic acid. Oils imbibe this air pretty rapidly, in proportion to their tenuity, though they cannot be made to imbibe ſo much of it as water can.

Equal quantities of whale oil, olive oil, and oil of turpentine, being fully impregnated with this aerial fluid, the olive oil was rendered quite colourleſs and the whale oil became reddiſh, after having imbibed ſix or eight times their bulk of air. In this manner they continued in glaſs jars confined by quickſilver about a month, when the oil of turpentine was become of a beautiful amber colour, the olive oil darker, and the whale oil darker ſtill. Their tenacity was not apparently increaſed, but their ſmell was extremely pungent by the eſcape of the acid air.

Vitriolic ether imbibes this acid air, almoſt as readily as water does; but its properties do not appear to be changed. Phoſphorus gave no light in this air; but the upper ſurface of it turned black, and the ſurface of the quickſilver upon which it lay had a deep yellow or blackiſh kind of ſcum upon it, as if it had been in part diſſolved by the acid. Liver of ſulphur ſlowly abſorbed a quantity of vitriolic acid air, without ſuffering any perceptible change in its properties. Very dry charcoal abſorbed a quantity of vitriolic acid air, without producing any remarkable effect either in the remaining air or upon the charcoal, excepting that the latter had acquired a pungent ſmell. Vitriolic acid air diſſolved camphor pretty well, and reduced it to a tranſparent liquor. Water being admitted to it, the camphor re-aſſumed its natural ſolid form, but ſeemed to have acquired acidity of taſte.

When the electric ſpark is taken in this acid air, the inſide of the glaſs tube in which it is confined is covered with a blackiſh ſubſtance, the air itſelf being diminiſhed. In this experiment, the electric exploſion is much more effectual than the ſame quantity of electricity in ſparks. The black matter ſeems to be produced by a portion of the mercury which confines the vitriolic acid air, and is partly diſtributed through it, or diſſolved in it. It is probable that part of the vitriolic acid combines with the mercury, and is precipitated with it in the form of globules of ſuch extreme minuteneſs as to appear black. In what manner the electric ſhock operates, whether by entering into the combination, or by altering the ſpecific heat of the compound, or ſimply by the concuſſion which may throw the particles ſuddenly within the ſphere of attraction, cannot be well explained for want of a ſufficient number of facts *.

Though the vitriolic acid does not emit any elaſtic fluid by the uſual proceſs of boiling in an open veſſel, yet it appears to ſuffer ſome change in its component parts

* Prieſtley on Air, 1790, ii. 323.

when heated in a glaſs tube hermetically ſealed and nearly exhauſted. After the acid had been thus made to boil for ſome time, a denſe white vapour appeared in quick motion at a diſtance above the acid; and though, on withdrawing the fire, that vapour diſappeared, it inſtantly re-appeared on renewing the heat. When the tube was cool, it was opened under water, and a quantity of air ruſhed out, though the acid had been thus made to boil violently while it was cloſing, ſo that there could not have been much common air in the tube. This air was found to be rather better in point of reſpirability than common air; but Dr. Prieſtley does not appear to have examined its properties in other reſpects.

A quantity of denſe vitriolic acid being boiled in a glaſs retort, and the vapour paſſed through a red hot earthen tube glazed inſide and out, and filled with pieces of broken tubes, the liquor that diſtilled over was found to be the ſame thing with water impregnated with vitriolic acid air. The oil of vitriol uſed in this proceſs was 714 grains, and the liquor collected was 154 grains. At another time, when 762 grains of oil of vitriol, of the ſpecific gravity of 1856, was uſed, the quantity of volatile acid was 462 grains, of the ſpecific gravity of 1340. In theſe proceſſes a large quantity of dephlogiſticated air was afforded of the pureſt kind, the quantity in the laſt experiment being 130 ounce meaſures *.

In theſe experiments the vitriolic acid appears to have been decompoſed, and converted into volatile vitriolic acid and dephlogiſticated air, which is generally admitted to be the principle of acidity. As ſulphur is converted into vitriolic air by combuſtion, which vitriolic air produces the volatile or ſulphureous acid by combination with water, and this likewiſe becomes converted into common vitriolic acid by expoſure to the air, from which it doubtleſs attracts the vital part, as we have already obſerved to happen when vitriolic and common air are confined together; ſo, by a contrary gradation, it appears that the denſe vitriolic acid being ignited by the contact of red hot earthen tubes, loſes a part of its vital air, and becomes converted into volatile vitriolic acid, from which the vitriolic air may be expelled by heat, and in which the preſence of ſulphur may be exhibited when combined with alkaline air. It appears therefore that vitriolic air has the ſame relation to vitriolic acid, as nitrous air has to the acid of nitre. Both are capable of ſuſtaining ignition without being decompoſed, and are therefore ſeparable by that proceſs from the larger portion of vital air which they are capable of ſaturating at a lower temperature. Thus ſulphur, ignited or burned, in contact with vital air attracts no more than produces the compound called vitriolic acid air, which afterwards, at a lower temperature, when united with water, becomes vitriolic acid, by attracting a larger portion of vital air from the atmoſphere: and, on the contrary, vitriolic acid being ignited emits the redundancy of vital air, and becomes converted into vitriolic acid air.

It muſt be admitted, however, that we are far from clearly underſtanding the theory of proceſſes of this nature, in which combinations and decompoſitions are apparently effected by mere heat. It is probable that, in many caſes, we do not ſee the whole of the facts; it is certain that our imperfect acquaintance with the conſtituent parts of ſuch apparently ſimple principles as ſulphur and vital air muſt greatly diminiſh the accuracy of our inferences; and to this we may add that, in the various methods of changing the temperature of bodies in the ſolid, fluid, or elaſtic forms, there may be, and really do exiſt, differences, eſpecially in the higher temperatures, which we either overlook, or cannot eſtimate with ſufficient facility and exactneſs to infer all the conſequences they may produce. It ſeems to ariſe from difficulties of this kind that

* Prieſtley, in Philoſ. Tranſ. vol. lxxix. page 290.

we

we cannot reconcile the following decompoſition of vitriolic acid air, when long heated with water in perfectly cloſed veſſels, with its permanency in the foregoing experiments.

Dr. Prieſtley expoſed water, impregnated with vitriolic air, encloſed in glaſs tubes hermetically ſealed, to a ſand heat for many weeks. In three weeks the water had depoſited a quantity of black powder, and a bit of matter exactly reſembling ſulphur. The proceſs being continued for ſeveral months, cryſtals of ſulphur were formed in the glaſs, which were tried by burning. Near half the common air in the tube, above the liquor, had diſappeared, and the remainder was perfectly noxious. Dr. Prieſtley thinks that the volatile acid, in this expanded and confined ſtate, uniting with the dephlogiſticated air in the tube, firſt formed vitriolic acid, and that this acid uniting with the phlogiſton formed the ſulphur.

The vitriolic acid forms peculiar and well-known compounds with earths, alkalis, and metals. Siliceous earth does not appear to be affected by it. With argillaceous earth it forms alum. This ſalt has an auſtere or aſtringent taſte; is ſoluble in about 15 times its weight of water at the temperature of 60°, and in a much leſs quantity at higher temperatures, from which it is ſeparated in permanent or ſlightly efflorescent cryſtals. It is fuſible in a moderate heat, and froths up till its water of cryſtallization is diſſipated; at which period it has the form of a white friable ſubſtance called calcined alum, which retains the greateſt part of its acid when not too much heated, and may be again reſtored to its original form by again adding the water of cryſtallization it had loſt by the heat.

The acid in alum is not ſaturated. If a ſolution of alum be boiled upon clay, a conſiderable portion of the latter will unite with the ſalt, and form a combination which is much leſs ſoluble than the alum itſelf.

With calcareous earth, the vitriolic acid forms gypſum or plaiſter of Paris. This ſaline ſubſtance is plentifully found in nature, and is known by different names, according to its texture and external appearance. *See* GYPSUM. It is ſoluble in about five hundred times its weight of water at the temperature of 60°, and has for that reaſon been claſſed among earths.

With ponderous earth it forms the ponderous ſpar or marmor metallicum. With magneſia it forms Epſom ſalt, which is ſoluble in its own weight of water at the temperature of 60°, cryſtallizes by evaporation, and effloreſces by expoſure to a dry air.

The vitriolic acid in combination with vegetable alkali forms the ſalt uſually known by the name of vitriolated tartar. This requires ſixteen times its weight of water to diſſolve it, and forms permanent hard cryſtals by evaporation.

Mineral alkali combined with this acid forms Glauber's ſalt, which requires only three times its weight of water to diſſolve it at a mean temperature. It is much more ſoluble in hot than in cold water, and may therefore be ſeparated from the hot ſaturated ſolution either by cooling or evaporation. Its cryſtals are uſually large and well formed; but they loſe their water of cryſtallization, which amounts to near half their weight, by expoſure to the air, and fall into an efflorescence or white powder.

Vitriolic acid with volatile alkali forms vitriolic ammoniac. Twice its weight of cold, or an equal weight of hot water, is ſufficient to diſſolve it; and conſequently it is ſeparable either by cooling or by evaporation. Its cryſtals are permanent, or ſlightly diſpoſed to attract moiſture and deliqueſce. Chemiſts differ with reſpect to its volatility; but it is probable that it cannot ſuſtain any moderate heat without decompoſition, either of its acid or alkali.

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The vitriolic acid acts upon and diſſolves many of the metals, and forms combinations deſcribed under the reſpective titles of thoſe metals.

In the diſtillation of the metallic and earthy ſalts, the laſt portions of this acid are decompoſed by the heat like the nitrous; a product of vitriolic air and vital air being afforded, and in ſome caſes actual ſulphur. Decompoſition or phlogiſtication of this acid likewiſe takes place when it is treated with combuſtible bodies. We have already ſeen, that in this combination there is an eſcape of vitriolic air or phlogiſticated acid, doubtleſs attended with the addition of a portion of vital air to the combuſtible. In the dry way, when vitriolic ſalts are heated with charcoal, the eſcape of vitriolic air is much more ſpeedy, abundant, and eaſy, becauſe the attraction of the inflammable ſubſtance for the vital air of the acid greatly facilitates the diſengagement of the vitriolic air, which conſiſts of another portion of acid united with ſulphur. And in this proceſs, if ſulphur conſiſt, as ſtated by the theory of Stahl, of phlogiſton and the acid of vitriol, the combuſtible body muſt have emitted phlogiſton while it imbibed the vital air.

It is ſeen, therefore, that the vitriolic acid, originally produced by the combuſtion of ſulphur, is again reduced to that ſubſtance by the action or effect of ſome other more combuſtible body, which may deprive it of vital air, and perhaps add the principle of inflammability, if ſuch a common principle be admitted to exiſt. The modern diſcoveries on elaſtic fluids have exhibited a great variety of facts, which clearly indicate this leading circumſtance of the acidification and reduction of this ſubſtance. In the earlier times of chemiſtry, this was with juſtice thought a diſcovery of the firſt magnitude, though effected in a leſs direct method. The greateſt difficulty in the attempt naturally conſiſted in the volatile nature of the vitriolic acid, which being rendered ſtill more ſo by the addition of any combuſtible body, would of courſe elude the endeavour to ſubject it to any conſiderable degree of heat; and the means of examining the volatile products were not then known. It was in all probability the former circumſtance which led the great Stahl, the founder of the phlogiſtic theory, to direct his attention to the vitriolic combinations in which the acid is more fixed by its adheſion to a baſe. Vitriolated tartar, or fixed alkali, was the ſalt he choſe. This conſiſts of the vitriolic acid combined with fixed alkali; and ſtill more to prevent the acid from riſing when phlogiſticated or changed by a combuſtible body, he added an equal weight of fixed alkali to the ſalt. This mixture he fuſed in a crucible, with half a part of powdered charcoal, and, after well ſtirring the whole together, and expoſing it to a ſtrong heat of ſhort continuance, he poured it out all ſparkling upon a greaſed ſtone. The compound was ſoluble in water, and proved to conſiſt in a great meaſure of liver of ſulphur, or the combination of ſulphur and an alkali, contaminated indeed by a portion of charcoal held in ſolution. This liver of ſulphur was accordingly diſſolved in water, and by the addition of an acid the ſulphur was ſeparated from the alkali and fell down.

In theſe experiments it is evident that the charcoal converted the vitriolic acid into ſulphur, or volatile vitriolic acid, which was detained by the redundant alkali, and that the acid, laſt added in the watery ſolution, cauſed a ſeparation of the ſulphur, by ſeizing the alkali in conſequence of its ſtronger affinity.

The electric ſpark, paſſed between two ſurfaces of vitriolic acid confined in a glaſs tube, decompoſes the acid. Vital air eſcapes, and the acid is rendered ſulphureous or phlogiſticated.

The ſulphureous or volatile vitriolic acid forms combinations with earths, alkalis, and metals; but its attraction to theſe baſes is exceedingly weak. Expoſure to air for a length of time changes theſe ſalts into common vitriolic ſalts, doubtleſs in the

ſame manner as it converts ſulphureous acid into common vitriolic acid; that is to ſay, by affording vital air, and perhaps by receiving phlogiſton, as it may be diſſipated.

For farther particulars reſpecting this acid, *ſee* SULPHUR; AIR, HEPATIC; AIR, DEPHLOGISTICATED; and the ſeveral metals.

ADAMANT. *See* DIAMOND.

ADAMANTINE SPAR. This ſtone, which comes to us from the peninſula of hither India, and alſo from China, has not engaged the attention of the chemical world till within a few years paſt. It is remarkable for its extreme hardneſs, which approaches to that of the diamond, and by virtue of which property it is uſed for poliſhing gems.

Two varieties of this ſtone are known in Europe. The firſt comes from China. It is cryſtallized, in ſix-ſided priſms, without pyramids, whoſe length varies from half an inch to an inch, and thickneſs is about three quarters of an inch. Its colour is grey of different ſhades. The larger pieces are opake; but thin pieces and the edges of the priſms are tranſparent. Its fracture is brilliant, and its texture ſpathoſe, which cauſes its ſurface to appear lightly ſtriated. Its cryſtals are covered with a very fine and ſtrongly adherent cruſt of plates of ſilvery mica mixed with particles of red felt-ſpar. A yellow ſuperficial covering of martial vitriol was obſerved upon one ſpecimen.

This ſtone is ſo hard that it not only cuts glaſs as eaſily as a diamond, but likewiſe marks rock cryſtal and ſeveral other hard ſtones. Its ſpecific gravity is 3710.

Small cryſtalline grains of magnetical ferruginous calx are occaſionally found in the adamantine ſpar of China, which may be ſeparated by the magnet when the ſtone is pulverized.

The ſecond variety, which comes from India, is called Corundum by the inhabitants of Bombay. It differs from the former by a white colour, a texture more evidently ſpathoſe, and laſtly, becauſe the grains of magnetical iron are ſmaller than in the former ſpecimens, and are not interſperſed through its ſubſtance, but only at its ſurface.

The chemical properties of this ſtone are very ſingular. It obſtinately reſiſts decompoſition by any of the known methods. Mr. Klaproth ſubmitted 300 grains of adamantine ſpar to fuſion with 15 parts of mineral alkali, in a ſilver crucible, for twelve ſucceſſive times, continuing each time for five hours as ſtrong an heat as the veſſel could ſupport. After each fuſion, he ſoftened the maſs with boiling diſtilled water, filtered it, and precipitated by acids the ſmall portion of earth the alkali had diſſolved; and laſtly, he digeſted for ſeveral times, alternately, in concentrated and boiling acids, the portion which had not been decompoſed.

In this long and painful method of treating the adamantine ſpar alternately with mineral alkali and concentrated acids he ſucceeded at length in decompoſing it. This operation employed all his opportunities of leiſure for more than three months, when he found the ſtone (excluſive of the magnetical calx of iron, which, without being one of the conſtituent parts of the ſpar, forms one fifth of its weight) to conſiſt of clay two parts, united with one part of a peculiar earth whoſe nature is not yet determined *.

This earth is not ſiliceous, becauſe, though inſoluble in acids, it does not combine with fixed alkalis by fuſion.

M. Morveau poſſeſſes two ſpecimens of the adamantine ſpar found in France †.

* Klaproth in the Berlin Mem. for 1788, quoted in the Annales de Chemie, vol. i. † Ibid.

ADOPTER. A veſſel with two necks placed between a retort and a receiver, and ſerving to increaſe the length of the neck of the former. *See* APPARATUS.

AFFINITY, CHEMICAL. *See* ATTRACTION, ELECTIVE.

AGARIC is a fungus growing on the trunk of the common larch tree, from which turpentine is extracted. Three fourths of its weight is a reſinous ſubſtance, and the reſt a ſlimy mucilaginous earthy matter, ſo tenacious as ſcarcely by any method to be diſſolved in water.

AGATE. The oriental agate is almoſt tranſparent, and of a vitreous appearance. The occidental is of various colours, and often veined with quartz or jaſper. It is moſtly found in ſmall pieces covered with a cruſt, and often running in veins through rocks like flint and petroſilex, from which it does not ſeem to differ greatly. When agates contain arboriſations they are called mocha ſtone. Theſe are conſiderably valued when the internal figure nearly reſembles ſome animal or plant.

AGGREGATE. When bodies of the ſame kind are united, the only conſequence is, that one larger body is produced. In this caſe, the united maſs is called an aggregate, and does not differ in its chemical properties from the bodies from which it was originally made. Elementary writers call the ſmalleſt parts into which an aggregate can be divided without deſtroying its chemical properties, integrant parts. Thus the integrant parts of common ſalt are the ſmalleſt parts which can be conceived to remain without change; and beyond theſe, any farther ſubdiviſion cannot be made without developing the component parts, namely, the alkali and the acid.

AIR is the generic name for ſuch inviſible and exceedingly rare fluids as poſſeſs a very high degree of elaſticity, and are not condenſable into the liquid ſtate by any degree of cold hitherto produced. This laſt circumſtance is the only diſtinctive criterion between air and vapour; for vapor is condenſable by cold. The air of the atmoſphere was formerly thought to conſiſt of one uniform fluid excluſively poſſeſſing the permanently elaſtic ſtate; and in the few inſtances wherein the earlier chemiſts took notice of the elaſtic products of their operations, theſe products were uſually ſuppoſed to conſiſt of atmoſpheric air. Modern philoſophers, among whom Dr. Prieſtley occupies the higheſt place, inſomuch that he may with juſtice be ſtyled the father of this branch of natural philoſophy, have diſcovered a conſiderable number of aerial fluids. Theſe conſiſt of, 1. Alkaline air. 2. Common or atmoſpheric air. 3. Dephlogiſticated or vital air. 4. Dephlogiſticated nitrous air. 5. Fixed air. 6. Fluor acid air. 7. Hepatic air. 8. Inflammable air. 9. Marine acid air. 10. Nitrous air. 11. Phlogiſticated air. 12. Phoſphoric air. 13. Vitriolic air.

AIR, ALKALINE. If the concrete volatile alkali, or common ſal volatile of the ſhops, be heated, it aſſumes the elaſtic ſtate, but conſiſts either totally, or for the moſt part, of vapour, and not air. This vapour, or the ſalt itſelf, is a combination of pure volatile alkali and fixed air, and is quickly condenſed in the ſolid form as before. If the ſame concrete ſalt be heated, either in ſolution with water, or with the addition of a ſmall quantity of that fluid, the ſame diſpoſition to ſublime is exhibited, but the water detains the alkali, while the fixed air eſcapes, contaminated indeed with alkali, which riſes afterwards. But when the cauſtic volatile alkali, which conſiſts of the pure alkali itſelf diſſolved in water, is heated, the alkali riſes together with a much leſs quantity of water than is ſufficient to hold it in ſolution in the denſe fluid ſtate. Part of this water impregnated with alkali is condenſed in a ſmall veſſel interpoſed between the retort in which the cauſtic alkali is heated, and the mercurial apparatus over which the air is received. *See* APPARATUS. The

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reſt of the alkali paſſes forward in the permanently elaſtic ſtate into an inverted jar over mercury.

As the procuring of alkaline air by heating the cauſtic volatile alkali is attended with all the expence of originally manufacturing the alkali from ſal ammoniac, it ſoon occurred to the diſcoverer, Dr. Prieſtley, that this air might be more cheaply obtained by the original proceſs with the ſal ammoniac itſelf. This laſt ſalt conſiſts of volatile alkali in combination with marine acid, and the method of diſengaging the volatile alkali together with water only conſiſted formerly in diſtilling a mixture of ſal ammoniac with three fourths of ſlaked lime. It will be ſeen that this mixture did not afford a ſufficient quantity of water in the firſt ſtage, or indeed in any ſtage of the operation, to condenſe the whole of the alkali which was diſengaged: for Dr. Prieſtley found that the greateſt part of the product is in the permanently elaſtic ſtate, and conſequently was loſt in the common operation.

The heat of a candle expels a prodigious quantity of alkaline air from this mixture; at the ſame time that the lime unites with the marine acid. It is neceſſary that alkaline air ſhould be received over mercury, becauſe it is readily abſorbed by water, with which it forms the fluid called cauſtic volatile alkali, or commonly ſpirit of ſal ammoniac with lime. Dr. Prieſtley found, by a rough trial, that ten parts by weight of water abſorbed four of alkaline air, reckoning the ounce meaſure to weigh ſomething more than half a grain, and the bulk of the water was increaſed by the addition of one fifth of its original magnitude. The abſorption of alkaline air by water does not ſeem to conſiſt of the whole of the fluid indiſcriminately, for after the water ceaſes to imbibe alkaline air which has ſtood for a conſiderable time upon it, it will imbibe other alkaline air newly produced. The pureſt and ſtrongeſt fluid volatile alkali is obtained by ſaturating water with this air; for which purpoſe the apparatus of Woulfe is peculiarly advantageous.

Cauſtic fixed alkali affords no elaſtic fluid by heat, the vapour expelled from it being nothing but water.

When a mixture of alkaline and marine acid air is made over mercury, a beautiful white cloud is formed, and a quantity of the elaſtic fluid diſappears; at the ſame time that a ſolid white ſalt is formed by the ſubſidence of the cloud, which was found to be common ſal ammoniac, or the marine acid united to the volatile alkali. The ſmell and the permanency of this white ſalt differs according to the redundance of either of the airs in its compoſition. The common ſal ammoniac is obtained when both are in due quantity; but, if either prevail, the compound is much more diſpoſed to evaporate.

Nitrous air admitted to alkaline air likewiſe occaſioned a whitiſh cloud, and part of the air was abſorbed; but it preſently grew clear again, leaving only a little dimneſs on the ſides of the veſſel. It is probable that the alkaline air united with ſome nitrous vapour or acid which might be preſent in the mixture; for, when water was admitted, the alkaline air was abſorbed, and the nitrous air remained in poſſeſſion of its peculiar properties.

Fixed air admitted to alkaline air formed oblong and ſlender cryſtals, which croſſed one another, and covered the ſides of the veſſel in the form of net work. Theſe muſt have conſiſted of the common or concrete volatile alkali, though perhaps with a redundancy of either principle according to its abundance in the mixture.

Inflammable air exhibited no particular appearance when mixed with alkaline air. Water, as in the former experiment, abſorbed the alkaline air, and left the inflammable air as it was before. It was remarkable, however, that the water which was

admitted to them became whitiſh, and that this white cloud ſettled in the form of a white powder to the bottom of the veſſel. Dr. Prieſtley does not appear to have examined its properties, perhaps becauſe its quantity was too ſmall.

Common air and alkaline air ſtanding together for ſeveral days, and afterwards ſeparated by the addition of water, which abſorbed the latter fluid, did not appear to have any action upon each other, at leaſt as far as was indicated by the teſt of nitrous air: for the common air was as much diminiſhed in this way of trial after the operation as before.

Phlogiſticated air, or common air which had been diminiſhed by ſtanding over a mixture of iron filings and ſulphur, was likewiſe unchanged by mixture with alkaline air: for when this laſt was abſorbed by water, the remaining phlogiſticated air was equally unchanged by the teſt of nitrous air.

Spirit of wine imbibes alkaline air as readily as water, and ſeems to be as inflammable afterwards as before. Alkaline air contracts no union with this aerial fluid; but oil of turpentine and eſſential oil of mint abſorbed a very ſmall quantity of it, without however having ſuffered any perceptible change in their properties. Ether imbibed alkaline air pretty freely, without any change of colour or diminution of its inflammability. It alſo evaporated as readily as before; but Dr. Prieſtley did not aſcertain this laſt fact with particular attention.

Sulphur, nitre, common ſalt, and flints, were put to alkaline air without imbibing any part of it; but charcoal, ſpunge, bits of linen cloth, and other ſubſtances of the ſame kind, ſeem to condenſe this air upon their ſurfaces. A piece of the inſpiſſated juice of turnſole being made very dry and warm, abſorbed a great quantity of this air, by which it contracted a moſt pungent ſmell, but its colour was not changed.

Alum undergoes a very remarkable change by the action of alkaline air. It becomes opake progreſſively from the ſurface inwards, and in this ſtate perfectly reſembles alum which has been roaſted. Dr. Prieſtley imagines that the alkaline air ſeizes upon the water that enters into the conſtitution of crude alum, and which would have been expelled by heat; but as roaſted alum likewiſe imbibes alkaline air, it ſeems moſt probable that this laſt ſubſtance unites with the redundant portion of acid which that ſalt contains.

Phoſphorus gave no light in alkaline air, and made no laſting change in its dimenſions. It varied indeed a little, being ſometimes increaſed and ſometimes diminiſhed; but after a day and a night it was in the ſame ſtate as at firſt. Water imbibed this air juſt as if nothing had been put to it.

Copper wire was not affected by remaining ſeveral hours in alkaline air, a circumſtance probably owing to the want of vital air to calcine the metal, as it is found in the proceſſes with this metal and volatile alkali that ſuch calcination is neceſſary in order that a mutual combination may take place.

Marine acid abſorbed alkaline air, and formed a little of the white ammoniacal ſalt, ſuch as was afforded when the marine acid air and the aerial fluid are mixed. A little remained unabſorbed and tranſparent, but upon the admiſſion of common air to it, it inſtantly became white. Vitriolic acid alſo formed a white ſalt with alkaline air, and this did not riſe in white fumes.

Alkaline air is ſlightly inflammable, though it extinguiſhes a candle dipped into it repeatedly; but at each time the flame was conſiderably enlarged by the addition of another flame of a pale yellow colour, and the laſt time this light flame deſcended from the bottom of the veſſel to the top. Theſe ſucceſſive differences in the appearance ſeem to depend upon the admixture of the common air which aſſiſted the inflammation.

Dr.

Dr. Prieſtley aſcertained that alkaline air is heavier than common inflammable air, by putting a quantity of the latter into a veſſel, and then adding half the quantity of alkaline air, and to this a like quantity of marine acid air. The white cloud was formed as uſual, but it did not riſe within the ſpace occupied by the inflammable air; ſo that the inflammable air had kept its place above the other without mixing with it. That the alkaline air is lighter than the acid air is ſhewn from the formation of the cloud on their mixture; for it begins at the bottom, and gradually reaches the top, when the acid air is laſt added; but when the acid air is put to the alkali, the whole becomes cloudy immediately quite to the top of the veſſel.

Alkaline air, which, according to the general law of vaporous or elaſtic fluids, becoming condenſed, produces heat when diſſolved in water, produces, on the contrary, cold when it is added to ice. The ice becomes very ſpeedily fluid, and doubtleſs, by its obtaining the fluid ſtate, abſorbs more heat than the condenſation of the air is capable of affording.

When acid and alkaline airs are mixed over mercury, the quantities of acid air abſorbed are various, according to the ſeveral kinds made uſe of. Of marine acid air and alkaline air equal bulks diſappear by mutual combination. Two meaſures of alkaline air ſaturate one of vitriolic. The ſame proportion is obſerved between alkaline and fluor acid air. Fixed air does not remarkably differ from this laſt proportion. The red vapour of nitrous acid ſeems to require about five times its bulk of alkaline air to ſaturate it; but in this there is much uncertainty on ſeveral accounts.

The electric ſpark or ſhock taken in alkaline air has a red colour ſimilar to that which it has in inflammable air; and this treatment cauſes the air to expand at length to about three times its former bulk, at the ſame time that it becomes no longer abſorbable in water. Ignition of a glaſs retort containing alkaline air likewiſe rendered it permanent over water and inflammable; and the ſame effect was produced by heating pieces of crucible or porcelain in alkaline air by a burning glaſs, and alſo by paſſing the alkaline air through an ignited earthen tube.

It remained to be determined in what manner this change in the alkaline air took place. For this purpoſe Dr. Prieſtley, whoſe experiments and diſcoveries have ſupplied the whole of the preceding part of this article, heated ſeveral of the metallic calces in alkaline air, with a view to reduce them to the metallic ſtate, as he had before done by the ſame proceſs with inflammable air. Maſſicot, or the calx of lead, was firſt tried. The lead was revived, and the reſidue of the air was the fluid called phlogiſticated air. Hence it ſhould ſeem, if we might ſpeak of phlogiſticated air and inflammable air as ſimple ſubſtances, that the alkaline air conſiſts of an intimate combination of both; that this union is deſtroyed by electricity, which of courſe muſt enlarge the bulk of the whole, becauſe diſengaged inflammable air has a much leſs denſity than any other aerial fluid. The quantity of lead in theſe experiments was always leſs than a bulk of inflammable air equal to that of the alkaline air would have reduced: from which circumſtance, as the alkaline air was convertible into an inflammable fluid of three times its original bulk, the Doctor is diſpoſed to think that the phlogiſticated air contains a very conſiderable portion of phlogiſton or inflammable matter which might elſe have reduced a larger portion of metal. But as the general tenor of his conduct has ever been unprejudiced by theory, he does not diſguiſe the facts, that the inflammable air from alkaline air may not be the ſame as that procured by the action of acids upon metals, and that ſome of the maſſicot uſed in theſe experiments was capable of affording fixed air by heat. This

laſt ſubſtance, when expelled, would unite with ſome of the air, and precipitate it in the form of the concrete alkali; and to this I would likewiſe add, that it may eaſily be ſuppoſed that the effect of the calx in attracting inflammable air may be conſiderably leſs when an intimate combination, ſuch as the volatile alkali, is to be deſtroyed, than when the inflammable air is preſented alone and diſengaged, and conſequently that leſs of the lead would be revived in the former, than the latter caſe. It may be obſerved, that the concluſions are nearly the ſame, whether we ſuppoſe the inflammable air as phlogiſton to have combined with the calx itſelf, or whether we ſuppoſe it to unite with the vital air of the calx, and reduce it by depriving it of that ſubſtance.

Glaſs of antimony abſorbed part of the alkaline air when it was heated by the burning glaſs in that fluid, and there was an appearance of metallic globules. The Doctor could not obtain the ſame appearance in inflammable air.

When ſcales of iron were heated in alkaline air, the quantity of the latter was much increaſed, and became ſtrongly inflammable. No water was afforded in this proceſs. The iron was revived, being perfectly ſoluble in diluted vitriolic acid, and had loſt one grain in twenty-four. In this experiment, the heat neceſſary to revive the iron appears to have been ſufficient to decompoſe more of the alkaline air, than was neceſſary to revive the iron.

Red precipitate was heated in the ſame manner in alkaline air. The conſequence was, that the mercury was revived, and at the ſame time a conſiderable quantity of water was produced: the reſidual air contained a portion of vital air. In another experiment, the quantity of dephlogiſticated air was ſtill more conſiderable; and in a third, an exploſion took place. It appears, therefore, that in theſe experiments the mercury was reduced by the mere heat, a thing well known to be practicable; that vital air was expelled from the mercurial calx, as is uſual in ſuch reductions; that the heat was ſufficient to convert part or the whole of the alkaline air into inflammable and phlogiſticated airs; that the vital air had remained unchanged in mere mixture with the principles of the alkaline air, when the heat had been moderate; but that in the caſe of the exploſion the heat had probably been ſuch as to cauſe the ignition and ſudden combination of the vital and inflammable airs; and laſtly, that the water which appeared and was depoſited from the airs was a conſequence of their combination, whether it be ſuppoſed to be really compoſed of inflammable and vital air, or only ſeparated from them when they unite to form nitrous acid, fixed air, or any other ſubſtance. *See* WATER.

Scheele has obſerved, that volatile alkali is decompoſed when kept a long time in digeſtion with the nitrous acid and manganeſe, or when ſal ammoniac is diſtilled from the ſame metallic calx. He remarks likewiſe that volatile alkali is decompoſed by the calx of gold, mercury, and other metals. In theſe ſeveral decompoſitions he obtained phlogiſticated air, which he obſerves in general is afforded whenever the phlogiſton of volatile alkali, which he takes to be one of its component parts, is attracted by any other body. Bergman concludes, from his own experiments upon fulminating gold, as well as from thoſe of Scheele, that the volatile alkali contains phlogiſton, and that whenever this principle is taken from it by virtue of a ſuperior attraction, an elaſtic fluid is diſengaged, which probably conſtitutes the other principle of the volatile alkali. Mr. Kirwan likewiſe obſerves, in his notes on the treatiſe of Scheele upon air and fire, that the calx of gold takes phlogiſton from the volatile alkali, at the ſame time that a kind of air is ſuddenly formed, which from its properties, as diſcovered by Scheele, appears to be phlogiſticated air.

From

From reflecting on theſe general facts, the excellent Berthollet entertained an expectation of arriving at a more accurate knowledge of the nature of volatile alkali, and by that means explaining a number of natural operations, in which this alkali is either formed or deſtroyed *.

He firſt endeavoured to determine the products obtained from ammoniacal nitre, or the combination of nitrous acid and volatile alkali. For this purpoſe he diſtilled two ounces of the dry ſalt in a ſmall glaſs retort, from which proceeded a recurved tube, communicating in the manner of figure 2, with a bottle ſurrounded with ice, for the purpoſe of condenſing aqueous vapours or acid. For greater ſecurity, another of theſe bottles was interpoſed between the retort and a jar, inverted over water, and deſigned to receive the aerial products. By heat carefully applied the whole was diſtilled, excepting one gros of ammoniacal nitre which was not decompoſed. During the operation, a large quantity of dephlogiſticated nitrous air was diſengaged, which Mr. Berthollet conſiders as nitrous air, containing a ſmall portion of vital air; and in the two veſſels ſurrounded with ice was contained one ounce and forty-three grains of a fluid conſiderably acid. This liquor was diſtilled on a water bath. Four gros thirty-two grains of ammoniacal nitre, which had been volatilized in the preceding diſtillation, now remained in the retort; and the acid liquor which came over was then ſaturated with vegetable alkali without affording the ſmalleſt indication of the preſence of volatile alkali. Laſtly, he evaporated this ſaturated liquor on a water bath, and obtained nothing but pure water, with fifty-four grains of nitre left behind in the retort, which, according to Bergman's valuation, would contain nearly twenty-ſeven grains of alkali, nine grains of water, and eighteen of pure acid. Hence he ſtates the products of the two ounces to be, excluſive of what remained in the retort at the firſt diſtillation,

Liquor contained in the bottles - -	1 ounce	43 grains,
Ammoniacal nitre contained in the liquor	4 gros	32 grains,
Nitrous acid contained in the ſame liquor	———	18 grains,
And conſequently water formed - -	3 gros	65 grains.

From this deduction, on which many remarks might be made, he concludes that aqueous inflammable air (taking the compoſition of water as an admitted fact) is one of the principles of volatile alkali.

This ingenious chemiſt having aſcertained that the aerated or dephlogiſticated marine acid contains vital air, and that the cauſtic volatile alkali unites with this acid with an effervеſcence and diſengagement of phlogiſticated air, at the ſame time that the volatile alkali is no longer found, concludes that the inflammable air of the alkali forms water by uniting with the vital air of the acid, and conſequently that the other principle of the volatile alkali muſt be phlogiſticated air. In confirmation of this, he quotes the experiments of Prieſtley which we have already recited, wherein water was produced by heating metallic calces in vital air. He likewiſe ſtates an experiment of his own to the ſame effect. Copper was diſſolved in the volatile alkali, and the dried ſalt was expoſed to diſtillation. The product was water and phlogiſticated air, and the copper was completely revived. A portion of the volatile alkali came over without decompoſition, which likewiſe held a ſmall portion of copper in ſolution.

The properties of fulminating gold, which have aſtoniſhed and embarraſſed the chemical world for a long time, have been happily brought in confirmation of this theory. M. Berthollet had the courage to diſtil the volatile alkali from this combi-

* Memoirs of the Pariſian Acad. for 1785.

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nation. This is diſengaged from the calx without decompoſition, when the heat is very moderate and carefully managed. He likewiſe detonated ſeven grains of fulminating gold in a retort, and collected the air, which proved to be phlogiſticated air. It is not eaſy to imagine how ſo conſiderable a quantity of this dangerous compoſition could be exploded in any apparatus calculated to collect the air without being attended with a certainty of its flying in pieces. This was however accompliſhed by the ſimple contrivance of including a quantity of water, which had been deprived of its air by boiling, along with the fulminating gold. The mouth of the retort was left open, and the water kept boiling until it had entirely evaporated; conſequently the internal part of the retort contained only ſteam or aqueous vapour, until the inſtant that its bottom became dry and the exploſion took place. The aerial product was then taken out by plunging the retort into water. It was proved to be phlogiſticated air by the teſt of electricity, which diminiſhed it when mixed with inflammable air. This philoſopher proceeded to determine the proportions of inflammable and phlogiſticated air which enter into the formation of volatile alkali. From the weight of volatile alkali ſuppoſed to be contained in fulminating gold, and taken to be equal to the exceſs of weight of this precipitate beyond that which is afforded by fixed alkali, together with other data equally indirect, he had formerly concluded that the inflammable air amounted to one ſixth of the weight, or two thirds of the bulk of volatile alkali. He afterwards proceeded to avail himſelf of the more direct method of electricity and the ſubſequent exploſion. In this way, by making the experiment with every precaution, he found that ſeventeen parts of alkali received an augmentation of bulk equal to ſixteen. This was introduced into the eudiometer of Volta by ſucceſſive portions, together with a due quantity of vital air; the whole amounting to five meaſures of the latter, and four meaſures of the electrified alkaline air.

Theſe nine meaſures were reduced to 4 $\frac{1}{10}$, ſo that there were 4 $\frac{4}{10}$ deſtroyed. Care was taken in this experiment to add a ſurplus of vital air, for the greater certainty of deſtroying the whole combuſtible part. But he ſtates it as a known fact, that combuſtion cauſes nearly 145 meaſures of inflammable air to diſappear, together with 74 parts of vital air. Whence it follows that the 4 $\frac{4}{10}$ deſtroyed repreſent 2 $\frac{9}{10}$ of inflammable gas, and 1 $\frac{1}{10}$ of phlogiſticated air, it being aſcertained from his other experiments that the part which is not combuſtible conſiſts of that fluid. And admitting the weight of phlogiſticated air to be eleven times that of an equal bulk of inflammable air, the weight of this laſt contained in volatile alkali, compared with that of the phlogiſticated air, will be as 29 to 121.

Theſe facts are applicable to a variety of phenomena, in which volatile alkali has unexpectedly made its appearance. When a few ounces of powdered tin are mixed with moderately ſtrong nitrous acid, and, after they have ſtood together a minute or two, about half an ounce of fixed alkali is added to them, a very pungent ſmell of volatile alkali is immediately perceived. The experiment ſucceeds equally with lime inſtead of alkali, and may be accounted for by conſidering that the nitrous acid being deprived of its vital air, its remaining principle, namely phlogiſticated air, would be ſet at liberty, if the inflammable air extricated from the tin were not at hand to combine with it and form volatile alkali. And the explanation will be the ſame, whether the metal be ſuppoſed to emit its phlogiſton in the form of inflammable air, or the water to be decompoſed into its principles of vital and inflammable air, in which caſe the former will enter into the calx together with the vital air of the nitrous acid. The ſubſequent addition of the fixed alkali or of the lime

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ſerves only to diſengage the volatile alkali from the mixture, and render it more immediately obvious to the ſenſes.

From this and many other experiments it appears, that the component parts of volatile alkali are readily united when they meet together in the condenſed ſtate, though no means have yet been deviſed to combine them when in the elaſtic ſtate. This laſt difficulty ſeems to depend on the reſiſtance which one or both of them make to quitting the elaſtic ſtate; whether ſuch reſiſtance depend upon the matter of heat in combination, the diſtance of the particles in this expanded ſituation, or any other circumſtance hitherto unexamined.

Whenever iron ruſts in contact with water, there is an extrication of inflammable air; and if iron filings moiſtened with diſtilled water be encloſed in a proper veſſel together with phlogiſticated air, there is a production of volatile alkali, as is ſhewn by the change of colour ſuſtained by a piece of paper ſtained with the rind of blue radiſh, and included within the glaſs. This takes place in the courſe of twenty-four hours; but the change is much more rapid when nitrous air is uſed inſtead of phlogiſticated air. Volatile alkali is generated and the nitrous air is converted into dephlogiſticated nitrous air, which Dr. Auſtin *, with many other chemiſts, ſuppoſes to conſiſt of nitrous air deprived of a portion of phlogiſticated air, or, which is the ſame thing, poſſeſſing a ſurplus of vital. But if ſo, why ſhould it not contain nitrous acid? *See* ACID, NITROUS, page 38.

AIR, ATMOSPHERICAL, *or* COMMON. The immenſe maſs of permanently elaſtic fluid which ſurrounds the globe we inhabit muſt conſiſt of a general aſſemblage of every kind of air which can be formed by the various bodies that compoſe its ſurface. Moſt of theſe, however, are abſorbed by water, a number of them are decompoſed by combination with each other, and ſome of them are ſeldom diſengaged in conſiderable quantities by the proceſſes of nature. Hence it is that the lower atmoſphere conſiſts of vital air mixed with phlogiſticated air, together with moiſture and the occaſional vapors or exhalations of bodies. The upper atmoſphere ſeems to be compoſed of a large proportion of inflammable air, a fluid of ſo much leſs ſpecific gravity than any other, that it muſt naturally aſcend to the higheſt place, where being occaſionally ſet on fire by electricity, it appears to be the cauſe of the aurora borealis and fire-balls. It may eaſily be underſtood, that this will only happen on the confines of the reſpective maſſes of common atmoſpherical air, and of the inflammable air; that the combuſtion will extend progreſſively, though rapidly, in flaſhings from the place where it commences; and that when by any means a ſtream of inflammable air, in its progreſs towards the upper atmoſphere, is ſet on fire at one end, its ignition may be much more rapid than what happens higher up, where vital air is wanting, and at the ſame time more definite in its figure and progreſſion, ſo as to form the appearance of a fire-ball.

That the air of the atmoſphere is ſo tranſparent as to be inviſible, except by the blue colour it reflects when in very large maſſes, as is ſeen in the ſky or region above us, or in viewing extenſive landſcapes; that it is without ſmell, except that of electricity, which it ſometimes very manifeſtly exhibits; altogether without taſte, and impalpable; not condenſable by any degree of cold into the denſe fluid ſtate, though eaſily changing its dimenſions with its temperature; that it gravitates and is highly elaſtic, are among the numerous obſervations and diſcoveries which do honour to the ſagacity of the philoſophers of the laſt century. They likewiſe knew that this fluid

* Phil. Tranſ. vol. lxxviii. p. 384.

is indiſpenſably neceſſary to combuſtion; but no one except the great, though neglected, John Mayow, appears to have formed any proper notion of its manner of acting in that proceſs.

The air of the atmoſphere, like other fluids, appears to be capable of holding bodies in ſolution. It takes up water in conſiderable quantities, with a diminution of its own ſpecific gravity; from which circumſtance, as well as from the conſideration that water riſes very plentifully in the vaporous ſtate, in vacuo, it ſeems probable that the air ſuſpends vapor, not ſo much by a real ſolution, as by keeping its particles aſunder, and preventing their condenſation. Water likewiſe diſſolves or abſorbs air.

Mere heating or cooling does not affect the chemical properties of atmoſpherical air; but actual combuſtion, or any proceſs of the ſame nature, converts it into phlogiſticated air. Whenever a proceſs of this kind is carried on in a veſſel containing atmoſpherical air, which is encloſed either by inverting the veſſel over mercury, or by ſtopping its aperture in a proper manner, it is found that the proceſs ceaſes after a certain time; and that the remaining air, which is about three fourths of the whole bulk, is of ſuch a nature as to be incapable of maintaining any combuſtion for a ſecond time, or of ſupporting the life of animals. From theſe experiments it is clear, that one of the following deductions muſt be true: 1. The combuſtible body has emitted ſome principle, which, by combining with the air, has rendered it unfit for the purpoſe of farther combuſtion: Or, 2. It has abſorbed part of the air which was fit for that purpoſe, and has left a reſidue which was of a different nature: Or, 3. Both events have happened; namely, that the pure part of the air has been abſorbed, and a principle has been emitted which has changed the original properties of the remainder.

The facts muſt clear up theſe theories. The firſt induction cannot be true, becauſe the reſidual air is not only of leſs bulk, but of leſs ſpecific gravity than before. The air cannot therefore have received ſo much as it has loſt. The ſecond is the doctrine of the philoſophers, who deny the exiſtence of phlogiſton on a principle of inflammability; and the third muſt be adopted by thoſe who maintain that ſuch a principle eſcapes from bodies during combuſtion. This reſidue was called phlogiſticated air in conſequence of ſuch an opinion.

In the opinion that inflammable air is the phlogiſton, it is not neceſſary to reject the ſecond inference, that the air has been no otherwiſe changed than by the mere ſubſtraction of one of its principles: for the pure or vital part of the air may unite with inflammable air ſuppoſed to exiſt in a fixed ſtate in the combuſtible body; and if the product of this union ſtill continues fixed, it is evident that the reſidue of the air after combuſtion will be the ſame as it would have been if the vital part had been abſorbed by any other fixed body. Or, if the vital air be abſorbed while inflammable air or phlogiſton is diſengaged, and unites with the aeriform reſidue, this reſidue will not be heavier than before, unleſs the inflammable air it has gained exceeds in weight the vital air it has loſt; and if the inflammable air falls ſhort of that weight, the reſidue will be lighter.

It ſeems moſt probable that the air of the atmoſphere conſiſts of a vital and a noxious part, from the fact that, when fixed bodies have been burned or calcined (for example, mercury converted by heat into precipitate per ſe), the vital air may be again extricated from them. This, inſtead of being mere atmoſpherical air, is found to be much more effectual for maintaining combuſtion, and is almoſt totally abſorbed in that proceſs, inſtead of leaving a reſidue ſuppoſed to be changed by phlogiſtication. Hence therefore it may be inferred, that the air called phlogiſticated air does not in

fact receive phlogiſton or any principle in combuſtion; becauſe, if ſuch a principle were emitted, it muſt in ſome way appear in the ſecond combuſtion with vital air. And, on the other hand, there is no proof that phlogiſticated air conſiſts of reſpirable or vital air thus changed; for there is no unequivocal experiment to ſhew that this kind of air can by any means be obtained from the part or reſidue ſuppoſed to be phlogiſticated.

We have frequently, however, found occaſion to repeat the obſervation, that the theories of chemiſtry which are carried farther than experiments have yet proceeded, may all be applied without manifeſt contradiction in the explanation of the phenomena; though the ſimpleſt inductions are certainly to be preferred, becauſe the moſt readily underſtood, the moſt probable, and the moſt eaſily rectified by new facts when they come to be diſcovered.

The general facts are, that combuſtible bodies take vital air from the atmoſphere, and leave three fourths of phlogiſticated air; and that when theſe two fluids are again mixed, in the proportion of one fourth of vital with three fourths of phlogiſticated air, they compoſe a mixture not differing from atmoſpherical air by any teſt hitherto diſcovered.

The reſpiration of animals produces the ſame effect on atmoſpherical air as combuſtion does, and their conſtant heat appears to be an effect of the ſame nature. When an animal is included in a limited quantity of atmoſpherical air, it dies as ſoon as the air is vitiated, and no other air will maintain animal life but that which maintains combuſtion; that is to ſay vital air, or a mixture which contains it. Pure vital air maintains the life of animals much longer than atmoſpherical air.

There are many proviſions in nature by which the proportion of vital air of the atmoſphere, which is continually abſorbed in reſpiration and combuſtion, is again reſtored to that fluid. In fact there appears, as far as an eſtimate can be formed of the great and general operations of nature, to be at leaſt as great an abſorption of the phlogiſticated air and emiſſion of vital air as is ſufficient to keep the general maſs of the atmoſphere at the ſame degree of purity. Thus in volcanic eruptions there ſeems to be at leaſt as much vital air emitted or extricated by fire from various minerals as is ſufficient to maintain the combuſtion, and perhaps even to meliorate the atmoſphere. And in the bodies of plants and animals, which appear in a great meaſure to derive their ſuſtenance and augmentation from the atmoſphere and its contents, it is found that a large proportion of phlogiſticated air exiſts. Moſt plants emit vital air in the ſunſhine, from which it is highly probable that they imbibe and decompoſe the air of the atmoſphere, retaining its noxious part, and emitting the vital part. Laſtly, if to this we add the decompoſition of water, which, though a conteſted point, is far from being diſproved, there will be numerous occaſions in which this doctrine will ſupply us with diſengaged vital air; while by a very rational ſuppoſition its inflammable part may be conſidered as having entered into the bodies of plants for the formation of oils, ſugars, mucilages, &c. from which it may be again extricated.

To determine the reſpirability or purity of air, it is evident that recourſe muſt be had to its comparative efficacy in maintaining combuſtion, or any other equivalent proceſs. Among theſe proceſſes the acidification of nitrous air is one of the moſt elegant and effectual. This aerial fluid (*ſee* NITROUS ACID, page 38) is not rapidly imbibed by water, and may therefore, for temporary uſe, be received over it. Dr. Prieſtley found, by a variety of experiments, that when nitrous air and any other air are mixed, they undergo no change, if the latter be totally unfit to ſupport

combuſtion or animal life; but if the contrary, the red cloud is formed, and the whole bulk of the mixture is diminiſhed by a quantity which is ſo much the greater, accordingly as the air in queſtion is of a quality more ſuited to thoſe purpoſes. This diminution he likewiſe proved to conſiſt of a proportional part of the air which is tried, together with as much of the nitrous air as is required to produce the effect; ſo that if the nitrous air be duly proportioned to the effect it will wholly diſappear.

The trial of the purity of common air by means of nitrous air has not however been found to exhibit ſuch remarkable differences between the air taken up at various places as their known ſalubrity or unhealthineſs might have afforded reaſon to expect. Two reaſons may be offered to account for this. The firſt is, that a ſmall difference in the purity of the air of a place may have a conſiderable effect on the health of thoſe who are obliged to breathe it for a long ſucceſſion of time: the ſecond is, that the effects of nitrous air being the ſame upon all elaſtic fluids which contain equal proportions of vital air, however greatly their other component parts may differ, it will only be ſhewn that the airs are equally ſalubrious, as far as depends on their proportion of vital air, though they may be by no means ſo with regard to their noxious parts.

There are ſeveral ingenious contrivances called EUDIOMETERS (which ſee) for the mixing of nitrous and other airs, and meaſuring their diminution. As theſe however may not be eaſily procured in particular ſituations, and more eſpecially as Dr. Prieſtley, whoſe experience is greater than that of any other philoſopher, does not uſe them, it ſeems preferable to deſcribe his method inſtead of any other in this place.

He firſt provides a phial containing about an ounce of water, which he calls the air meaſure. This he fills with air, by having firſt filled it with water, and placed it over the funnel in the ſhelf of his pneumatic apparatus, fig. 3, and when it is filled he ſlides it along the ſhelf, always obſerving that there be a little more air than is wanted. The phial being thus exactly filled with the air he is about to examine, and care being taken that it be not warmed by holding in the hand, he empties it into a jar of about an inch and a half in diameter, and then introduces to it the ſame meaſure of nitrous air, and lets them continue together about two minutes. The doctor chooſes to have an overplus of nitrous air, that he may be ſure that its effect may be the utmoſt poſſible. If he finds the diminution of theſe two meaſures to be very conſiderable, he introduces another meaſure of nitrous air; but the pureſt vital air will not, he believes, require more than two meaſures of nitrous air.

Sometimes he leaves the common and nitrous air in the jar all night, or a whole day; but he always takes care, whenever he compares two kinds of air, that both ſhall remain the ſame time in the veſſels before he notes the degree of diminution.

When the preceding part of the proceſs is over, he transfers the air into a glaſs tube about three feet long, and one third of an inch wide, carefully graduated according to the air meaſure, and divided into tenths and hundredth parts, ſo that one of the hundredth parts will be about one ſixth or one eighth of an inch. Then immerſing the tube in a trough of water, ſo that the water in the inſide of the tube ſhall be on a level with the water on the outſide, he obſerves the ſpace occupied by the aerial mixture, and expreſſes the reſult in meaſures and decimal parts of a meaſure according to the graduation of the tube.

Thus if one meaſure of nitrous air be added to one of another aerial fluid, and the remaining mixture after diminution be $1\frac{26}{100}$ meaſure, he ſays, in ſhort, that the meaſure

meaſure of the teſt was 1.26. But if two meaſures of nitrous air be added, he is careful to mention that circumſtance.

It is ſome trouble to graduate a tube in this manner; but when it is once done the application of it is extremely eaſy. As it ſeldom happens that a glaſs tube is of an equal diameter throughout, the doctor generally fills that part of the tube which contains one meaſure, with quickſilver; and then dividing the quickſilver into ten parts by weight, he puts them again ſeparately into the tube in order to mark the primary diviſions. The weighing is rendered very eaſy by the help of a glaſs tube drawn to a fine orifice, which ſerves to take up a ſmall quantity at a time as may be required in making the adjuſtment.

Common or atmoſpherical air loſes about one fourth of its bulk by any proceſs equivalent to combuſtion. This alſo happens when it is mixed with a quantity of nitrous air not greater than ſufficient to ſaturate it. In this caſe the nitrous air totally diſappears, as is proved from the obſervation that, when a ſmall quantity of nitrous air is added to a large quantity of atmoſpherical air, the remainder is always leſs than the original quantity of atmoſpherical air; but, on the contrary, the ſmalleſt quantity of atmoſpherical air added to a large quantity of nitrous air always makes ſome addition to its bulk, notwithſtanding the diminution which is ſuſtained by the whole mixture.

The electric ſpark repeatedly taken in common air diminiſhes it at leaſt as much as any other kind of combuſtion. Nitrous air is produced in this proceſs (*ſee* page 33) by the union of the vital and phlogiſticated airs, which is in fact the combuſtion of the latter. For this reaſon the experiment does not ſerve to ſhew that the electric ſpark itſelf is any thing more than diſengaged heat, if indeed heat be a ſeparate ſubſtance.

AIR, FIXED. The acid which is commonly known by the name of fixed air, abounds in great quantities in nature, and appears to be produced in a variety of circumſtances. It compoſes about one third of the weight of lime-ſtone, marble, calcareous ſpar, and other natural ſpecimens of calcareous earth, from which it may be extricated either by the ſimple application of heat, or by the ſuperior affinity of ſome other acid; moſt acids having a ſtronger action on bodies than this. This laſt proceſs does not require heat, becauſe fixed air is ſtrongly diſpoſed to aſſume the elaſtic ſtate. Water, under the common preſſure of the atmoſphere, and at a low temperature, abſorbs ſomewhat more than its bulk of fixed air, and then conſtitutes a weak acid. If the preſſure be greater, the abſorption is augmented. Heated water abſorbs leſs; and if water impregnated with this acid be expoſed on a briſk fire, the rapid eſcape of the aerial bubbles affords an appearance as if the water were at the point of boiling, when the heat is not greater than the hand can bear. Congelation ſeparates it readily and completely from water; but no degree of cold or preſſure has yet exhibited this acid in a denſe or concentrated ſtate of fluidity.

Fixed air is nearly twice as heavy as common air, and for that reaſon occupies the lower parts of ſuch mines or caverns as contain materials which afford it by decompoſition. The miners call it choke damp. The Grotto del Cano, in the kingdom of Naples, has been famous for ages on account of the effects of a ſtratum of fixed air which covers its bottom. It is a cave or hole in the ſide of a mountain, near the lake Agnano, meaſuring not more than eighteen feet from its entrance to the inner extremity; where if a dog or other animal that holds down its head be thruſt, it is immediately killed by inhaling this noxious fluid.

Fixed air is emitted in large quantities by bodies in the ſtate of the vinous fermentation (*ſee* FERMENTATION), and on account of its great weight it occupies the

apparently empty ſpace or upper part of the veſſels in which the fermenting proceſs is going on. A variety of ſtriking experiments may be made in this ſtratum of elaſtic fluid. Lighted paper, or a candle dipped into it, is immediately extinguiſhed; and the ſmoke remaining in the fixed air renders its ſurface viſible, which may be thrown into waves by agitation like water. If a diſh of water be immerſed in this air, and briſkly agitated, it ſoon becomes impregnated, and obtains the vivid taſte of Pyrmont water. In conſequence of the weight of the fixed air, it may be dipped out in a pitcher or bottle, which, if well corked, may be uſed to convey it to great diſtances. The effects produced by pouring this inviſible fluid from one veſſel to another have a very ſingular appearance: if a candle or ſmall animal be placed in a deep veſſel, the former becomes extinct, and the latter expires in a few ſeconds, after the fixed air is poured upon them, though the eye is incapable of diſtinguiſhing any thing that is poured.

When vegetable ſubſtances are expoſed to a ſtrong heat in veſſels partly cloſed, the volatile principles fly off; but combuſtion does not take place for want of air. The fixed reſidue is the inflammable ſubſtance called charcoal. For general purpoſes, wood is converted into charcoal by building it up in a pyramidical form, and covering the pile with clay or earth, leaving a few air holes, which are cloſed when the maſs is perfectly lighted, and by that means the combuſtion is carried on in an imperfect manner. Common charcoal when expoſed to heat in cloſed veſſels gives out a ſmall quantity of inflammable air, which ſeems extraneous to it; and if it be burned, it leaves a ſmall portion of earth, fixed alkali, and other ſalts. The greater part of charcoal therefore conſiſts of one inflammable ſubſtance: and it is found that if this be burned in a cloſed veſſel over mercury with vital air, the product is fixed air, and nothing elſe, as is proved by the reſidue after the fixed air has been abſorbed by cauſtic fixed alkali; for there is either no aerial reſidue, or the reſidue conſiſts of vital air as pure as at firſt *.

Hence it follows, that fixed air conſiſts of the inflammable matter of charcoal united to vital air. The antiphlogiſtian philoſophers conſider this matter as a peculiar combuſtible and acidifiable baſe, and thence infer the preſence of charcoal in all caſes where fixed air is extricated or produced; but, on the other hand, ſeveral of the phlogiſtians think themſelves juſtifiable in concluding that fixed air is produced by the union of inflammable air with vital air, when either of them is in the naſcent ſtate or ſtate of extrication.

When the electric ſpark † is paſſed through fixed air confined by mercury, the volume of air is augmented about one twenty-fourth part; and of this three fifths are abſorbed by a ſolution of cauſtic alkali, and the remainder is inflammable. An eminent philoſopher of the phlogiſtic opinion ſuppoſes this effect to ariſe from the decompoſition of the fixed air, whoſe vital air, combining more intimately with part of the inflammable air, forms water, the reſidue of this laſt air being diſengaged. But the chemiſt who made the experiment, accounts for it as follows, without ſuppoſing the fixed air to be decompoſed. The air of the atmoſphere and other elaſtic fluids are proved by experiment to be capable of retaining mercury in ſolution; ſo likewiſe in all probability does the fixed air; and they all retain much water. Whenever therefore the electric ſpark, by paſſing through this mixture of fixed air, mercury, and water, ignites a minute portion of it, the vital air of the water unites with and cal-

* Lavoiſier in Mem. Acad. Par. for 1781, p. 449.

† This experiment, firſt performed by Mr. Prieſtley, i. 248, has ſince been repeated by Van Marum and others. The experiment of Mr. Monge, quoted by Kirwan in his Eſſay on Phlogiſton, p. 193, ſecond edition, is that ſpoken of in the text; and the opinions are thoſe of Meſſrs. Kirwan and Monge.

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cines the mercury, while the inflammable air of the water is ſet at liberty, and the fixed air, like other acids, unites to the mercurial calx, and falls down with it. He ſuppoſes from analogy, that the water in the fixed air increaſes its volume by rarefying, and that the abſtraction of the water occaſions a contraction, while the diſengagement of the inflammable air produces a ſomewhat greater augmentation of bulks. In this way, ſuppoſing the water and mercury to be preſent in ſufficient quantity, the whole of the fixed air may enter into a ſolid combination, and nothing remains but inflammable air. Additional experiments muſt however be made before either opinion can be eſtabliſhed.

Fixed air does not appear to be ſtrongly diſpoſed to unite with argillaceous earth. Moſt clays however afford a ſmall quantity of this fluid by heat; and the ſnowy white ſubſtance reſembling chalk, and known by the name of lac lunæ, is found to conſiſt of clay ſaturated with fixed air. A ſaline ſubſtance, conſiſting of two ſix-ſided pyramids joined at one common baſe, weighing five or ſix grains, and of a taſte ſomewhat reſembling alum, was produced by leaving an ounce phial of water, impregnated with fixed air and a redundancy of earth of alum, expoſed to ſpontaneous evaporation for ſome months.

Calcareous earth and fixed air have a ſtrong attraction for each other. Moſt of the ſpecimens of calcareous earth abound with this acid; and the immediate precipitation of lime from lime-water is the teſt of the preſence of this acid.

Ponderous earth combines very ſtrongly with fixed air. This compound has been found in England and elſewhere.

Magneſia unites readily to a large proportion of fixed air.

The uſual method of procuring magneſia is by precipitation from a ſolution of Epſom ſalt, by adding an alkali which combines with the acid. When a mild fixed alkali is uſed, it is neceſſary that the ſaline ſolutions ſhould be boiling hot, and the ebullition continued for a ſhort time, in order to diſſipate a portion of fixed air, which would hold part of the magneſia in ſolution. From this cauſe it is, that perfectly mild vegetable alkali affords no precipitate when added to a ſolution * of Epſom ſalt at the temperature of 60°. The mineral alkali, which contains leſs fixed air than the cryſtallized vegetable alkali, likewiſe affords but a ſmall quantity of precipitate, unleſs heat be applied. Mild volatile alkali alſo poſſeſſes the property of affording no precipitate when added to a ſolution of Epſom ſalt in the cold. With a greater heat magneſia is ſeparated, and at a boiling heat it is again taken up, moſt probably forming a triple ſalt compoſed of vitriolic acid united to volatile alkali and magneſia. The ſaline combination of magneſia and fixed air is ſeparated in cryſtals from all theſe cold ſolutions by ſtanding uncovered; during which time the fixed air which held the magneſia in ſolution is no doubt gradually diſſipated. The cryſtals afforded when vegetable alkali is uſed are contaminated with vitriolated tartar, which ſeparates at the ſame time: thoſe obtained by mineral alkali are finer and purer; but the moſt beautiful and pureſt are obtained by leaving the ſolution to which volatile alkali has been added, expoſed for ſome days in an oblong veſſel.

This cryſtallized aerated magneſia has uſually the form of ſix-ſided priſms. It is almoſt taſteleſs; effloreſces in the air; becomes pulverent by heat by the loſs of

* One part Epſom ſalt, diſſolved in ſix parts of water, was mixed with one part of cryſtallized vegetable alkali, diſſolved in five parts water. Conſult Fourcroy in the Annales de Chimie, ii. 282, from whence the whole of this article reſpecting aerated magneſia is taken.

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its fixed air and water; is ſoluble in about forty times its weight of water, at the temperature of 55°. Half its weight conſiſts of fixed air, one fourth water, and one fourth magneſia; whereas the common aerated magneſia obtained by rapid precipitation contains forty parts magneſia, forty-eight fixed air, and twelve water.

All the earthy combinations of fixed air are nearly inſoluble in water; they are all more ſoluble with an exceſs of that acid than in mere water; and they all give out their fixed air by heat, except the native ſpecimen of aerated ponderous earth. This laſt contains no water; and water ſeems to be eſſentially neceſſary to enable bodies to aſſume the aerial form.

Fixed air has no action upon ſiliceous earth.

The three alkalis form concrete cryſtallizable ſalts when united with fixed air, which being in fact neutral ſalts, are much leſs active than the cauſtic or pure alkalis themſelves. Theſe ſalts ſtill continue to be called the mild alkalis, becauſe the fixed air, though it forms a large proportion of their weight, is diſplaced by moſt other acids, and therefore does not obviouſly ſeem to impair their alkaline properties: beſides which, as this volatile acid flies off in the elaſtic form, and is loſt in common experiments (exhibiting no other indication of its preſence than the violent ebullition which accompanies its eſcape), it was formerly overlooked, and even at the preſent time is not always ſufficiently attended to.

Alkaline air and fixed air unite, and form the concrete volatile alkali.

The combination of fixed air with inflammable ſubſtances has not been accurately examined. Metallic calces uſually contain more or leſs of this acid. Plumbago or black lead is the moſt remarkable compound into which it enters. This affords much fixed air; but chemiſts are not agreed with reſpect to its combuſtible part, ſome conſidering it as the mere principle of inflammability, and others aſſerting it to be iron. See PLUMBAGO, and alſo IRON.

AIR, HEPATIC. The fœtid vapor which is emitted by ſulphureous compounds has long ſince given riſe to various conjectures among the writers on chemical ſubjects; but it was not properly attended to until the great Scheele examined its properties in the permanently elaſtic form. This excellent chemiſt combined ſulphur by fuſion with quicklime, with manganeſe, and with fixed alkali. It appears from the facts that water was preſent in theſe operations. The air which was collected is the peculiar fluid ſince diſtinguiſhed by the name of hepatic air. He alſo found that ſulphur diſtilled with charcoal afforded the ſame elaſtic fluid; that ſulphur heated alone in a retort with common air occaſioned no change in its dimenſions, though its purity was diminiſhed. The change of dimenſions muſt have been too ſmall to be perceived by the method at that time uſed by Scheele. When the ſame experiment was repeated with inflammable air, the fluid acquired the ſmell of hepatic air, but differed from that fluid in not being ſoluble in water. This acute obſerver aſcertained moſt of the general properties of hepatic air, and concluded that it is a compound of ſulphur and phlogiſton with the matter of heat.

Bergman *, Senebier †, Gengembre ‡, and Kirwan §, have ſince made this fluid an object of ſucceſsful reſearch. Its general properties have been ſince compared and elucidated according to the French or antiphlogiſtic theory by M. Fourcroy ‖, who entirely adopts the ideas of M. Gengembre, and conſiders it as a compound of ſulphur and inflammable air.

To obtain hepatic air, liver of ſulphur made by fuſion of ſulphur with an alkali is

* On the artificial preparation of medicated waters, Eſſays, vol. i. † Recherches ſur l'Air Inflammable. ‡ Sçavans Etrangers, vol. x. § Phil. Tranſ. 1785. ‖ Acad. Par. for 1786.

placed in a body or glaſs veſſel provided with a recurved tube, and an acid is poured upon it. The hepatic air is then diſengaged with a conſiderable effervescence, and may be collected either over water or mercury. If water be uſed, it is neceſſary that it ſhould be heated to 80 or 90 degrees, at which temperature it diſſolves very little; and from the experiments of M. Senebier it ſeems that hepatic air is partly decompoſed by mercury, and therefore ought not to be received over that fluid. It muſt not however be diſguiſed, that the valuable courſe of experiments of Mr. Kirwan, referred to in the preceding paragraph, were all made over mercury, without any inconvenience or apprehenſion, though that philoſopher had the experiments of M. Senebier before him, and quotes this very fact as a reaſon why the experiments of the Genevan chemiſt are not to be depended on. It was the opinion of Bergman that the hepatic air exiſts ready formed in the hepar; but from the experiments of M. Gengembre and Kirwan, it is aſcertained that the hepar does not afford it by heat unleſs water be preſent: inſomuch that after the common air of the retort, and the fixed air which may be contained in the alkali, have paſſed over, there is no more air afforded, and the ſulphur ſublimes alone when the temperature is raiſed to ignition. But as the former has obſerved, the addition of a ſmall quantity of water enables it to give out a great quantity of hepatic air by diſtillation. Hence it follows, either that the water afforded one of the principles of the hepatic air, or that the preſence of this fluid is neceſſary to the aeriform ſtate. Another experiment ſeems to ſhew this in a more deciſive light. If marine acid air be added to very dry liver of ſulphur in powder, it turns it white; the ſulphur is ſeparated without any apparent commotion, and very little hepatic air is produced. The ſmall quantity of water in the acid air ſeems to be the cauſe of this laſt circumſtance; and though it may indeed be urged, with conſiderable probability, that the water already exiſting in the acid air ought to have been ſufficient to have produced the hepatic air according to either theory, yet it muſt be admitted that the neutral ſalt produced by the combination of the acid and alkali might have abſorbed the whole. This experiment, if repeated with the addition of a ſmall quantity of water, is attended with effervescence and the diſengagement of hepatic gas.

M. Gengembre is of opinion that the effect of water in the production of hepatic gas ariſes from its decompoſition. For though, according to the various experiments in which water is ſuppoſed to ſuffer decompoſition, it has not been ſhewn that the alkali, nor indeed the ſulphur, can ſeparate its principles, yet it is urged that, in conformity to many other examples in chemiſtry, the attraction of the ſulphur for vital air, by which it is converted into vitriolic acid, is greatly forwarded by the attraction which the alkali has to that acid, and by virtue of which it therefore aſſiſts the combination. In this way then, according to the antiphlogiſtians, it is that the vital air of water is diſpoſed of to convert one part of the ſulphur into vitriolic acid, while the other principle, namely inflammable air, is taken to combine with another portion of the ſulphur, and form hepatic air.

When iron and ſulphur are mixed together with a little water, they afford a large quantity of hepatic air by diſtillation, and the reſidue contains the ſalt of iron united to vitriolic acid; and ſo likewiſe, when the alkaline hepar is diſtilled with water, this air is emitted, and the reſidue contains the neutral ſalt formed by the combination of alkali with vitriolic acid. In theſe and ſimilar experiments the maintainers of the ancient theory muſt ſay that part of the ſulphur is converted into vitriolic acid by the loſs of its phlogiſton, and that, according to Scheele's inference, the diſengaged phlogiſton uniting with another portion of the ſulphur, together with the matter of heat, forms the hepatic air: and the abſolute neceſſity of water to the aeriform ſtate will account

account for the experiments not ſucceeding without that fluid. It muſt be confeſſed, however, that in the ſolution of theſe facts the antiphlogiſtic theory ſeems to poſſeſs the advantage, if the compounded nature of water be admitted; and even in that leading diſpute it affords no ſmall probability that water really contains vital air: for numerous facts ſhew that vitriolic acid contains vital air, and we know of none which ſhew that either ſulphur, or iron, or alkali contain it. But as the ſulphur becomes vitriolic acid, it muſt have derived vital air from ſome of the principles, and the water is the only one ſuſpected of containing it. In this way, the decompoſition of water and the volatilization of ſulphur in combination with inflammable air, may be applied to account for the various hepatic exhalations emitted from ſuch animal and vegetable ſubſtances as are known to contain ſulphur.

In Mr. Kirwan's excellent ſeries of experiments on hepatic air received over mercury, we find that the marine acid is the beſt adapted to the production of this air; that nitrous acid affords nitrous air alſo unleſs it be greatly diluted; that concentrated vitriolic acid indeed decompoſes the liver of ſulphur, but with the extrication of little air, unleſs aſſiſted by heat; that when the proportion of ſulphur in the hepar much exceeds that of the alkali, the ſtrong vitriolic acid poured upon it emits vitriolic acid very much loaded with ſulphur, which it depoſits in the courſe of a few hours with the loſs of at leaſt five ſixths of its former dimenſions. He found that oil of olives, charcoal, and alſo ſugar, afforded hepatic air by diſtillation with ſulphur, the latter of which had the ſmell of onions; but that plumbago afforded none.

The ſame chemiſt, in his endeavours to combine ſulphur with elaſtic fluids, obtained the following reſults. Sulphur heated in a retort with inflammable air acquired an hepatic ſmell, but afforded no hepatic air. Liver of ſulphur expoſed to fixed air for five days, at the temperature of 70°, became ſomewhat whitened on the ſurface, and the air had not an hepatic ſmell, but rather that of bread. The fixed air ſeems to have received a ſmall acceſſion of ſulphur or of hepatic air. Little effect was produced by expoſing ſulphur to marine acid air in a common temperature.

M. Haſſenfratz * attempted to diſcover the nature of ſulphureous airs by ſyntheſis. For this purpoſe he paſſed fixed air through ſulphur in fuſion, and the product was a ſulphureous fixed air which precipitated lime-water, and parted at the ſame time with its ſulphur, which was either left on the ſurface of the water, or ſent in a cloud to the bottom together with the calcareous earth. Nitrous air by the ſame treatment diſſolved ſome ſulphur, which it let fall when it was mixed with vital air. Phlogiſticated air alſo took up a portion of ſulphur which ſeparated by ſtanding over water. Vital air converted part of the ſulphur into volatile vitriolic acid, or vitriolic acid air, which was abſorbed; and another portion of the vital air ſuſtained a part of the ſulphur undecompoſed, which fell down when the vital air was united with nitrous air, or detonated with inflammable air. Atmoſpherical air produced an effect correſpondent to that of a mixture of vital and phlogiſticated air. And laſtly, inflammable air, paſſed through ſulphur in fuſion, produced hepatic air.

Mr. Kirwan has obſerved however, that no one has yet decompoſed hepatic air, ſo as to leave the inflammable air behind. The general character of his hepatic air received over mercury were the following: Its ſpecific gravity was greater than that of common air in the ratio of 11 to 10, when the barometer ſtood at 29.94 inches, and the thermometer at 67½°. It is inflammable, but never detonates with common

* Phil. Tranſ. lxxvii. p. 305.

air

air, and a very conſiderable proportion of this laſt fluid is required to enable it to be fired in a narrow-mouthed veſſel. M. Senebier did not find that his air received over water could be fired by the electric ſpark, though mixed with any proportion of reſpirable air. When hepatic air is burned there is a continual depoſition of ſulphur. Nitrous air enables hepatic air to burn partially; but equal proportions of vital and hepatic air explode with great violence.

Every ſpecies of hepatic air indicates a ſlight acidity by turning the tincture of litmus red, even though it has been waſhed in water, or previouſly diſſolved in and expelled from that fluid. With reſpect to ſolubility in water, the hepatic airs extracted from different materials vary conſiderably. In the temperature of 66° Mr. Kirwan found that water by ſlight agitation diſſolves two thirds of its bulk of alkaline or calcareous hepatic air extracted by marine acid; eight tenths of that extracted by means of the concentrated vitriolic, or the dilute nitrous or ſaccharine acids, at the temperature of 60°; ſeven tenths of that obtained by the acid of borax; nine tenths when acetous acid is uſed, or when ſulphur is boiled with oil of olives; and its own bulk of that produced by heating a mixture of ſugar and ſulphur. In general Mr. Kirwan imagined that which required the moſt heat for its production to be the moſt ſoluble; though in ſome inſtances, particularly that of acetous hepatic air, he obſerves that this circumſtance did not take place. The moſt remarkable phenomenon reſpecting the ſolution of hepatic air in water is, that though it is not expelled by water at a leſs heat than that of ebullition, yet it is ſpontaneouſly ſeparated in a few days, for the moſt part in the form of ſulphur, which falls down, and this though the bottle be ever ſo well ſtopped.

The action of hepatic and other aerial fluids on each other was alſo aſcertained by this chemiſt. Equal parts of common and hepatic air ſtanding over mercury for eight days did not ſuffer any change, though the ſurface of the mercury was ſlightly blackened. The ſame experiment was repeated with vital air, phlogiſticated air, inflammable air, marine acid air, and fixed air, without any change denoting mutual action. Vitriolic acid air produced a depoſition of ſulphur, and a very great diminution; inſomuch that ſix meaſures of hepatic air added at intervals to five of vitriolic air, left a reſidue of three meaſures only. This reſidue was not affected by nitrous air; extinguiſhed flame; and one meaſure of water agitated with two meaſures of this reſidue, abſorbed four tenths of its bulk, and left phlogiſticated air behind. The water appeared to have taken up a minute portion of vitriolic acid. When the precipitated ſulphur was waſhed with water, this fluid was found to contain ſome fixed air and a conſiderable portion of vitriolic acid.

Nitrous air in its uſual ſtate, in the proportion of nine meaſures to eight of the hepatic air, afforded a yellowiſh cloud of ſulphur with a diminution of about two meaſures, which in the courſe of forty-eight hours increaſed ſo much, that the reſidue was no more than ſix meaſures. The top and ſides of the jar were then covered with a cake of ſulphur, and the aerial reſidue was the fluid called dephlogiſticated nitrous air, in which a candle burns naturally.

When nitrous air was deprived of its adventitious acid by mixture with alkaline air, and waſhing with diſtilled water, it appeared to loſe about one ſixth of its bulk. Hepatic air, in the proportion of 7 to 8, being admitted to this nitrous air, produced no immediate effect; but in ſix hours, under the temperature of 72°, the whole was reduced to 5 parts or cubic inches, and a much whiter ſulphur was depoſited than in the preceding experiment. This air flaſhed with ſo much violence as to extinguiſh a candle dipped into it. The flame was exceedingly white and vivid, and from its

other properties this air ſeemed to be in the moſt perfect ſtage of that ſtate which Dr. Prieſtley calls dephlogiſticated, and in which it certainly appears to be highly diſpoſed to part with its vital air in a red heat. *See* ACID, NITROUS, page 31.

Alkaline and hepatic airs nearly deſtroy each other. Mr. Kirwan mixed equal parts of hepatic air from liver of ſulphur and of alkaline air. A white cloud was produced, which left a whitiſh ſcum on the ſides of the jar, and the mixture was reduced to one twelfth part of its original bulk. Of this reſidue half was abſorbed by water, and the remainder ſeemed to be common air of the veſſels. Seven meaſures of very pure alkaline air being added to ſix of calcareous hepatic air, a white cloud and a little white ſcum at firſt appeared; but in a few ſeconds the whole was reduced to ſix ſevenths of a meaſure, which was all abſorbed by the addition of two meaſures of water, except one ninth of a meaſure, and this reſidue extinguiſhed a candle. The ſcum appears to be almoſt liquid, and as ſoon as the jar is emptied of mercury, it breaks out into a white ſmoke with an exceedingly ſharp urinous ſmell. In his experiments, by adding alkaline air to the hepatic airs obtained from ſulphur and iron, and alſo from ſulphur and ſugar, the diminution was nearly as conſiderable, though very ſlow in the laſt caſe, and the ſmall reſidues unabſorbed by water were inflammable air.

Mr. Kirwan alſo examined the mutual action of hepatic air, and acid, alkaline, and inflammable liquors. One meaſure of concentrated vitriolic acid abſorbed two meaſures of hepatic air, except one tenth of a meaſure, and became whitened by a copious depoſition of ſulphur. It was difficult to mix it with nitrous acid without diluting it ſo as not to act upon mercury; but when the acid was ſo far diluted, it abſorbed eight tenths of its bulk of hepatic air, paſſed through the mercury, and the reſiduum detonated when the hepatic air from iron and ſulphur was uſed; but when the alkaline hepatic air was uſed, the reſiduum did not detonate, but burned with a blue and greeniſh flame, and ſulphur was depoſited on the ſides of the jar. Two meaſures of alkaline hepatic air being expoſed to one of ſtrong marine acid, were abſorbed by ſlight agitation all but one fifth of a meaſure. A third of a meaſure being added, there remained, after ſome agitation, but half a meaſure. Sulphur was precipitated as uſual; but the mercury over which the acid ſtood attracted it from the acid, for it was blackened, which did not happen when the former acids were uſed. The reſiduum burned juſt as pure hepatic air. Diſtilled vinegar abſorbs nearly its own bulk of air, and becomes ſlightly whitened; but by agitation it may be made to take up about twice its bulk, and then becomes very turbid.

One meaſure of cauſtic vegetable alkali, of the ſpecific gravity of 1.043, abſorbed nearly four meaſures of alkaline hepatic air, which rendered it at firſt brown, though it afterwards became clear by the depoſition of ſulphur upon the face of the mercury. Cauſtic volatile alkali, of the ſpecific gravity of 0.9387, abſorbed 18 times its bulk of hepatic air; and Mr. Kirwan, from the circumſtance that the greater the quantity of alkali the greater the abſorption, thinks this the beſt method of determining the ſtrength or real contents of ſuch alkaline liquors. The ſmoking liquor of Boyle is prepared with great facility by impregnating cauſtic volatile alkali with hepatic air.

Mr. Kirwan proceeds in his paper to relate his experiments on the combinations of hepatic air with oil of olives, new milk, oil of turpentine, ſpirit of wine, and ether. He aſcertains more minutely the properties of water, and alſo of alkaline liquors impregnated with alkaline air; and then treats of the theory of this elaſtic fluid, in which he avails himſelf of the modern doctrine of heat with peculiar felicity.

He finds it difficult to conclude that hepatic air conſiſts of any thing elſe than

ſulphur

ſulphur itſelf kept in an aerial ſtate by the matter of heat; and in particular he takes notice that every attempt to extract inflammable air from hepatic air, when drawn from materials that previouſly contained nothing inflammable, proved abortive; though, on the contrary, when it was procured from ſuch materials as could ſupply inflammable air, the ſmalleſt proportion of that fluid was detected. He ſhews that it cannot conſiſt of liver of ſulphur volatilized; becauſe it may be extracted from materials, ſuch as iron, ſugar, oil, and charcoal, which either contain no alkali, or a quantity altogether inconſiderable; and becauſe it is not decompoſable by marine or fixed air, which nevertheleſs decompoſe the liver of ſulphur. Neither can he admit of the ſuppoſition that the ſulphur in this air is ſuſtained in ſolution by the marine or vitriolic airs, becauſe it is producible from materials which contain neither of theſe acids; and from whatever ſubject it is obtained, it exhibits the characters of one and the ſame acid, namely, the vitriolic exceedingly weakened: and ſuch an acid, he obſerves, we may ſuppoſe ſulphur itſelf to be; for ſulphur unites with alkalis, calcareous and ponderous earths, and moſt metals, as a weak acid might; and, except a manifeſt ſolubility in water (a property likewiſe poſſeſſed in a very weak degree by ſome other concrete acids), it exhibits every character of acidity.

After thus rejecting the principal poſitions reſpecting the other compound matter which unites with ſulphur in the compoſition of hepatic air, our author continues to ſtate that Scheele has aſcertained that the matter of heat enters into its compoſition. This chemiſt found that acids excited much leſs heat in uniting with liver of ſulphur, whether alkaline or calcareous, than while uniting with a proportion of cauſtic fixed alkali or lime equal to that which enters into the compoſition of thoſe livers; whence he juſtly infers that the difference enters into the compoſition of the hepatic air produced. Mr. Kirwan, to prove the ſame thing, added marine ſelenite and marine Epſom to ſolutions of liver of ſulphur, and found that the hepar was really decompoſed, though no hepatic air was afforded: for the acid, he obſerves, having given out its ſpecific heat in uniting with the earths, had none to loſe or communicate on uniting with the alkali, and conſequently the ſulphur receiving none, could not be thrown into the aerial ſtate.

It is remarkable, continues he, that bodies capable of an aerial form receive the latent heat neceſſary for that form much more readily from a body that parts with its ſpecific heat than by the mere application of ſenſible heat. Thus aerated barytes, or the native combination of ponderous earth with fixed air, cannot be decompoſed by mere heat, though its air is eaſily ſeparated from it by an acid; and in the ſame manner antimony cannot be cleared of ſulphur even by vitrifaction, though it may by acids: ſo liver of ſulphur will not give hepatic air by mere heat, though it will by the intervention of an acid, even the weakeſt. And the reaſon he ſtates to be this: The matter of heat has no particular affinity with any ſubſtance, as is evident from its paſſing indifferently from any hot body to a colder, of whatever ſort or kind the bodies may be; but it is determined to unite with this or that body in a latent ſtate, in greater or leſs quantity, in proportion to the greater or leſs capacity of thoſe bodies to receive it. Now acids, by uniting to the alkaline baſis of the liver of ſulphur, expel the ſulphur, and give it their heat at the inſtant the ſulphur by its ſeparation has the capacity to receive it: whereas ſenſible external heat, acting alike on both the conſtituent parts of liver of ſulphur, ſeparates neither; or if it ſeparate them, yet by its ſucceſſive action it throws one of them into a vaporous ſtate firſt; and bodies that firſt acquire this ſtate can never after, he affirms, acquire an aerial ſtate by any ſubſequent acceſſion of heat.

He thinks that the vitriolic and nitrous acids are leſs adapted than the marine to

the production of hepatic air, moſt probably becauſe they have a ſtronger attraction to the ſulphur, and ſo detain it.

He accounts for the condenſation of hepatic air in water, from its great aptitude to give out its latent heat, particularly when in contact with ſubſtances to which it has any affinity. The precipitation of metals he aſcribes partly to its phlogiſticating the acids, and partly to its union with the metals themſelves.

The union and condenſation of hepatic and alkaline airs are readily accounted for by him, from the known affinity or elective attraction of theſe ſubſtances to each other: and for the contrary reaſon it is as eaſily underſtood why common dephlogiſticated, inflammable, and phlogiſticated airs have ſo little action upon it. The ſtrong action of vitriolic air is conſidered by him as pretty evidently ariſing from attraction, as is likewiſe the condenſation of nitrous air: but theſe circumſtances certainly require to be further inveſtigated in any theory.

On the whole therefore we may obſerve, that the theory of the compoſition of hepatic air from a combination of inflammable air and ſulphur being proved by no direct experiment but that conciſely related by Haſſenfratz in the Philoſophical Tranſactions, and inferred in other inſtances from the diſputed doctrine of the decompoſition of water, labours under ſeveral difficulties. This decompoſition is doubtful; the theory does not account for ſuch decompoſition taking place in the common inſtance where ſulphur is ſeparated from the hepar by an acid, and moſt of the facts it inſiſts upon may be as well explained upon Mr. Kirwan's theory. But, on the other hand, Mr. Kirwan's theory, though it opens an extenſive field of reſearch highly worthy of the utmoſt attention of chemiſts, labours under difficulties perhaps of equal magnitude. The materiality of heat is a conteſted point; and though the general facts may be treated of without neceſſarily requiring a deciſion of this great queſtion, yet there are ſo few yet inveſtigated, that the tranſitions of heat in particular inſtances do not ſtand much higher, for want of experimental proof, than any other ingenious hypotheſis, which, though it may be true, does not command our whole aſſent till farther proofs are exhibited. If the heat excited by chemical mixtures be ſuppoſed to depend on peculiar motions, the inferences reſpecting the changes of temperature in chemical operations will take a different form; and in decompoſitions, where four principles are concerned, the defect of elaſtic matter may be aſcribed to the effect of double affinities by thoſe who are diſpoſed to reject the doctrine of the tranſition of a matter of heat: and laſtly, though liver of ſulphur emits no hepatic air by mere heat, though it will by the intervention of an acid, and this is ſtated to depend on the acid giving out its latent heat when it enters into combination with the alkali; yet the ſame doctrine ſeems inſufficient to account for the production of hepatic air from liver of ſulphur when heated with mere water, unleſs the water be ſuppoſed alſo to have given out its heat in combining with the alkali. In this caſe we ought therefore to find water, alkali, and ſulphur; whereas in fact we find alkali and vitriolic acid: ſo that the water muſt either have dephlogiſticated the ſulphur, or afforded vital air, and by that means have converted it into vitriolic acid.

From theſe obſervations it appears that ſeveral experiments require to be made, and carefully repeated, before we can with certainty conſider ourſelves in poſſeſſion of a complete theory of hepatic air. And theſe reſearches are ſo much the more deſirable, as they nearly relate to the great queſtions of the compoſition of water and the conſtitution of acids.

AIR, INFLAMMABLE. All animal or vegetable ſubſtances which can be burned by heating in the open air, will afford inflammable air if heated in cloſed veſſels.

veſſels. It appears however to be a general rule or condition, that water ſhould be preſent in every caſe wherein inflammable air is produced, whether it be that this elaſtic fluid is moſt frequently afforded by the decompoſition of water, or whether it be indiſpenſably requiſite that water ſhould be preſent, and form part of every permanently elaſtic fluid. The inflammable air of animal or vegetable bodies is uſually mixed with air of other kinds, and with oleaginous or other immediate principles that are volatilized, and commonly remain ſuſpended for an unlimited time. Some of the metallic ſubſtances, during their ſolution in acids, or when ignited in contact with water or ſteam, emit or extricate inflammable air, which is conſidered to be the pureſt of any.

Chemiſts are not agreed whether inflammable air in all its varieties do conſiſt of one and the ſame matter vitiated by the admixture or ſolution of other ſubſtances, or whether theſe ſeveral kinds differ eſſentially from each other. Mr. Kirwan conſiders it as phlogiſton nearly pure, and conſequently infers that it eſcapes or is diſengaged in the combuſtion or calcination of metals, as it certainly does in all the ordinary inſtances of combuſtion. The philoſophers who hold this opinion muſt therefore moſt eminently maintain that pure inflammable air is one and the ſame ſubſtance, and that all combuſtible bodies whatever conſiſt of this identical matter combined with other baſes, by which its apparent properties are varied. The chemiſts of the antiphlogiſtian ſchool, though they do not admit of any general principle or cauſe of combuſtibility, except a ſtrong attraction for vital air, are nevertheleſs of opinion that pure inflammable air is one of the ſimpleſt bodies in nature, capable of diſſolving and ſuſpending a great variety of bodies, and that all the inflammable fluids yet diſcovered are nothing more than inflammable air holding other bodies in ſolution. They have accordingly availed themſelves of this poſition, together with the decompoſition of water, to account in a very elegant manner for many of the phenomena of nature and art. *See* HEPATIC AIR; VEGETABLE KINGDOM; WATER.

The proceſs for obtaining inflammable air in its pureſt ſtate conſiſts in diſſolving metallic bodies in acids, and collecting the elaſtic fluid which eſcapes during the efferveſcence that takes place. Theſe operations are treated of under the reſpective metals. That moſt commonly uſed conſiſts in diſſolving iron ſhavings or wire in diluted vitriolic acid. The ſpecific gravity of this inflammable air is uſually about one tenth of the common air of the atmoſphere, but it is ſaid to have been obtained ſeventeen times lighter. Of this however I very much doubt. From this extreme rarity it has been applied to float air-balloons, the inſtances of which are too numerous, and have too ſtrongly claimed the public attention, to be recited in this place. Inflammable air, like every other permanently elaſtic fluid which does not contain vital air, is incapable of maintaining combuſtion, or of taking fire by the electric ſpark, though it be itſelf eminently inflammable when vital air is preſent.

It is remarkable that all the acids which are capable of affording air by the ſolution of metals give inflammable air when the ſolution is properly conducted for that purpoſe, the nitrous acid excepted. But this acid, whether it be concentrated or diluted, affords only nitrous air more or leſs modified. From this and other circumſtances, the antiphlogiſtic philoſophers have inferred that the inflammable air which appears during the ſolution of metals is in all caſes produced by the decompoſition of the water with which the acid is diluted, and that the acid anſwers no other purpoſe in theſe operations than to facilitate the decompoſition by virtue of its attraction for the metallic calx: that is to ſay, according to this theory, of which Mr. de la Place is the author, the metal conſidered as a ſimple ſubſtance attracts vital air from the water, but not with ſufficient force to decompoſe that fluid, if it were not for

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the acid which tends to diſſolve this compound or metallic calx, and by that means facilitates the decompoſition of the water. The other principle of the decompoſed water, namely the inflammable air, flies off. *See* METALS.

The ſame queſtion concerning the decompoſition of water, and the exiſtence of phlogiſton or inflammable air in metals, continually preſents itſelf in accounting for the calcination and reduction of thoſe bodies by either of the two theories of chemiſtry. A large quantity of inflammable air is afforded when the ſteam of water is cauſed to paſs through a red hot iron tube, and indeed the ſame effect takes place when iron is immerſed for a length of time in pure water, though the quantity of inflammable air is not conſiderable. The iron itſelf is converted into that kind of calx which is known at the forges by the name of finery cinder. If this calx be heated with the burning glaſs in inflammable air, its metallic ſtate is reſtored, and water appears. Here alſo the antiphlogiſtians conclude that the water is decompoſed, and again recompoſed, during the revival of the iron. But the phlogiſtian philoſophers conſider the inflammable air as conſiſting chiefly of phlogiſton, which they ſtate to be one of the component parts of the iron; and conſequently they infer that finery cinder conſiſts of water united to the calx of iron, or iron deprived of its phlogiſton; and in the proceſs of revivification they affirm, that the inflammable air or its phlogiſton has combined with the calx of iron, and expelled the water which accordingly appears.

We have had frequent occaſion to ſtate the compoſition of water as being formed of vital and inflammable air in due proportions united at a red heat; and under the article WATER we have ſtated the experiments and inductions upon which this poſition depends. We ſhall therefore only remark in this place, that the combuſtion of vital and inflammable air affords water in very conſiderable quantities, together with nitrous acid and fixed air; and that the antiphlogiſtians conſider water as compounded of the two firſt, while they ſuppoſe the latter to be impurities ariſing from the preſence of phlogiſticated air and charcoal (*ſee* ACID, NITROUS; *and* AIR, FIXED): but that, on the other hand, Dr. Prieſtley, and ſeveral of the chemiſts who believe in the exiſtence of phlogiſton, think that the two airs produce nitrous acid and fixed air, according to the ſtate of the combuſtion, and that the water which appears is nothing elſe but that which pre-exiſted in the airs, and is eſſential to their ſtate of elaſtic fluidity.

The electric ſpark taken in any kind of oil produces inflammable air, and the ſame is the caſe with ether, except that this laſt is abſorbable by water, all but one third, which reſidue is the inflammable part. It is probable that the abſorbed part is vitriolic acid air. Spirit of wine likewiſe affords inflammable air by the ſame proceſs. Dr. Prieſtley obſerves, that the electric ſpark probably afforded the heat which is neceſſary to give the permanently elaſtic ſtate to the inflammable part and the water contained in theſe fluids.

In the extrication of inflammable air by heat from combuſtible ſubſtances the management muſt be different according to their reſpective natures. If the ſubſtances be fluid, heat applied to them directly makes no change in their conſtitution, except by volatilizing ſome of their principles, and decompoſing the ſolid reſidues. But when fluids are made to paſs in the form of vapour through tubes previouſly made red hot, in which they are neceſſarily expoſed to a red heat themſelves, they are readily decompoſed. Two ounces of ſpirit of wine by this treatment afforded about 1900 ounces of inflammable air, which burned with a white flame, and had no mixture of fixed air, which from experiment was found to weigh about 633 grains, and the watery reſiduum was 168 grains: ſo that there were 20 grains either loſt in the operation,

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or not accounted for in the eſtimate or inferred ſtate of the weight of the aerial product. Vitriolic ether alſo afforded much inflammable air without any fixed, as did alſo ſpirit of turpentine and olive oil mixed with whiting. From other experiments it is clearly aſcertained that flame conſiſts of inflammable air extricated from combuſtible bodies by heat, and taking fire by virtue of that heat and the acceſs of atmoſpheric air.

Sulphur incloſed in an earthen tube, and melted, affords inflammable air when ſteam is paſſed over it. This is of the ſame quality as is procured from iron by vitriolic acid; and conſequently affords the ſame field for diſcuſſion reſpecting the decompoſition of the water, or the phlogiſton of the ſulphur, as preſented itſelf in that caſe.

Inflammable air abſorbed by hot charcoal, and again expelled by immerſion in water, does not appear to have undergone any remarkable change in its properties: neither is it rendered leſs inflammable by the putrefaction of animal or vegetable ſubſtances in it. Plants alſo grow in this fluid, without impairing its inflammability. Water imbibes about one thirteenth of its bulk of this air, which being afterwards expelled by heat proved as inflammable as ever. Dr. Prieſtley found however that it became converted into reſpirable air by agitation in water: doubtleſs by the gradual admixture with the external air; for Haſſenfratz * appears to have clearly decided that water kept in contact with inflammable air for three years makes no alteration in the properties of that aerial fluid.

The electric ſpark taken in inflammable air has a red colour, but does not produce any other change in it but the depoſition of a ſmall quantity of acid †, which is probably extraneous to it. Change of temperature only changes its dimenſions for the time, when it has free liberty to expand: but when this fluid is expoſed to a red heat in a flint glaſs tube hermetically ſealed, it renders its ſurface perfectly black, moſt probably by reviving part of the calx of lead which enters into the compoſition of that body. This is rendered nearly certain by heating minium in the black tube, which immediately reſtores its tranſparency, no doubt by virtue of the pure air which it is known to emit by heat, and which again calcines the lead in the glaſs, while the minium itſelf approaches towards the metallic ſtate.

The revival of metals by heating them with a burning glaſs in inflammable air over mercury affords matter for ſpeculation of the moſt intereſting nature, and is explained according to both the theories of chemiſty. The general facts are, that the calces of lead, iron, mercury, and other metals, are reduced more or leſs to the metallic ſtate by ſuch treatment, while part of the inflammable air diſappears, and water is produced, the metals being, as in other caſes, of leſs abſolute weight than the calces from which they were obtained. It muſt be confeſſed that theſe experiments being upon ſo ſmall a ſcale, afford room for controverſy reſpecting the quantity and even the nature of the products; but taking the reſults as here ſtated, the inferences according to the ſeveral theories will be, firſt, according to the phlogiſtic theory it muſt be concluded that the inflammable air ſupplies phlogiſton to the metal and reduces it, and that the water has been either emitted by the calx, or depoſited by the inflammable air, the former of which is rendered probable from the power of calcining many of them by mere heating in contact with ſteam, and the latter from a variety of facts; or, according to the modern theory, the inflammable air unites with the vital air of the calx, and forms water, while the metal becomes reduced ſimply by the loſs of the air which calcined it. This is ſomewhat ſimpler; becauſe, according to the

* Annales de Chimie, I. 173. † Deſcription de la Machine Electrique de Teyler, I. 122.

other explanation, there muſt be two ways of calcining metals, one by combining them with water, and the other with vital air; a circumſtance which however is very far from being improbable.

Charcoal, which by heat, in contact with vital air, affords fixed air (ſee page 84), produces fixed air, together with an heavy kind of inflammable air, when ſteam is paſſed over it in a ſtate of ignition. This is concluded by Dr. Prieſtley, and many other chemiſts, to be an intimate combination of fixed air and inflammable air; as indeed ſeems to be ſufficiently proved by burning it with vital air, in which caſe a very conſiderable reſidue of fixed air is left. In ſome caſes, however, the quantity of fixed air thus obtained exceeds the whole weight of the inflammable air made uſe of; a circumſtance from which Dr. Prieſtley infers, that the fixed air is produced by a combination of the vital air with part of the inflammable air. But the French chemiſts, who conſider fixed air as an acid compoſed of vital air, united with a peculiar baſis which forms the greateſt part of the weight of charcoal, find no difficulty in accounting for this ſurplus of weight in the fixed air afforded or left after burning the heavy inflammable air: for they ſtate, that this laſt aerial fluid conſiſts of light inflammable air holding charcoal as the baſe of fixed air in ſolution; and they eaſily admit that this baſis may require more vital air to acidify it, than it before required of inflammable air to diſſolve it; in which caſe the fixed air will really be the heavieſt; not to mention that this fixed air may ſuſpend a larger quantity of water than the denſe inflammable air was capable of ſupporting.

The inflammable air of marſhes, which is emitted from the waters of ſtanding pools, drains, or privies, is the ſame as is produced by the putrefaction of organized ſubſtances, eſpecially animal matters, in water. It is emitted either before or after the production of the volatile alkali which is afforded by this laſt ſtage of ſpontaneous decompoſition. When it is conſumed by detonation with vital air, it leaves a reſidue of phlogiſticated air, and appears to differ from volatile alkali in the proportion of its principles and their want of combination, and alſo probably in the admixture of ſulphur or phoſphorus in ſome caſes, which may render it hepatic. It would not be difficult to exhibit ſituations in which inflammable air and phlogiſticated air might be emitted from putrefying ſubſtances without combining together, either in conſequence of their rapid acquiſition of the elaſtic ſtate, in which, either by the interpoſition of the matter of heat in a latent ſtate, or more probably by the particles being thrown beyond the uſual limits of chemical attraction, they would be kept apart: but this ſubject demands to be farther proſecuted by experimental reſearch. *See* WATER; IRON; PHLOGISTON.

AIR, MARINE, *or* MARINE ACID AIR. The marine acid readily aſſumes the permanently elaſtic ſtate by the application of heat, or by expelling it from combinations in which the diſengaged acid does not meet with a ſufficient quantity of water to hold it in ſolution. For the general properties of this aeriform acid, *ſee* ACID, MARINE.

AIR, MARINE, AERATED, *or* DEPHLOGISTICATED. *See* ACID, MARINE, AERATED, *or* DEPHLOGISTICATED.

AIR, NITROUS. This air is a modification of the nitrous acid from which part of its vital air has been ſeparated, at the ſame time that, according to the followers of Stahl, it has received phlogiſton or the principle of inflammability. *See* ACID, NITROUS.

AIR, NITROUS, DEPHLOGISTICATED. The nitrous acid upon its decompoſition or phlogiſtication is deprived of vital air, and receives phlogiſton according to the ancient theory. During this progreſs of change it becomes red nitrous acid, nitrous air, dephlogiſticated nitrous air, and laſtly, phlogiſticated air.

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The dephlogiſticated nitrous air, which is remarkable for its want of acidity, like the air called nitrous air, and its reſemblance to vital air in maintaining combuſtion, though like phlogiſticated air it is fatal to animal life, is produced only in certain circumſtances. Its conſtitution has not yet been clearly inveſtigated; and chemiſts have either ſuppoſed it to poſſeſs more vital air, and leſs phlogiſton, than nitrous air, or the contrary, accordingly as their attention was fixed upon one or other of its ſeveral properties. To me it ſeems to be a triple compound of vital air, phlogiſticated air, and inflammable air; and that the extrication of the former principle is facilitated, in certain circumſtances, by the diſpoſition of the two latter to combine, and form volatile alkali. But experiments are wanting to decide on this ſubject. *See* ACID, NITROUS.

AIR, PHLOGISTICATED. The reſidue of common air vitiated by combuſtion, or any other proceſs by which phlogiſton is ſuppoſed to be extricated, is moſt commonly known by the name of phlogiſticated air. The French call it azote; and ſome chemiſts diſtinguiſh it by the name of mephitis, or mephitic gas; none of which terms indeed denote any property excluſively poſſeſſed by this elaſtic fluid, though preferable to the former denomination, which refers to a ſuppoſition neither proved nor generally admitted. It is not however our buſineſs to change the names which are generally found in the writings of the beſt chemiſts; and for this reaſon we treat of it by the former appellation.

The characteriſtic properties of the ſeveral permanently elaſtic fluids are in general very eaſy to be exhibited. Thus vital air maintains combuſtion, and acidifies nitrous air; fixed air is abſorbed by lime-water, and precipitates the lime in a mild ſtate; alkaline air forms a white cloud with acids, beſides exhibiting its own peculiar ſmell; nitrous air ſpeedily forms nitrous acid by combining with vital air. And the other airs have alſo their reſpective criterions, which may be ſeen by conſulting the ſeveral articles. Phlogiſticated air however ſeems, in general, to have been diſtinguiſhed in no other way than by its not poſſeſſing any of the diſtinctive marks of the other known airs: ſo that, in all operations, the aerial reſidues which exhibited neither acid nor alkaline properties, nor were abſorbed by water, nor affected other kinds of air by combining with them and altering their dimenſions, have been called phlogiſticated air. The poſitive properties beſt calculated to diſtinguiſh this kind of air from every other, are, its forming nitrous acid by mixture with vital air, and electrization; and its forming volatile alkali by combination with inflammable air. The firſt of theſe operations is very long, and the latter, though continually performed by nature, cannot be done with any degree of facility in the operations of art; becauſe the elaſtic ſtate of the two fluids prevents their combination. *See* ACID, NITROUS, page 33; and alſo AIR, ALKALINE, page 75—78.

Among the great number of proceſſes by which the air of the atmoſphere may be rendered noxious, or deprived of its reſpirable part, it is evident that ſome of them will be better calculated than others to afford the reſidue of phlogiſticated air unmixed with other elaſtic fluids. The combuſtion of phoſphorus affording an acid not at all volatile is one of the beſt methods, but by no means among the cheapeſt. When common air is expoſed to liver of ſulphur, or to iron filings and ſulphur moiſtened, it becomes completely diveſted of vital or dephlogiſticated air; but in the firſt caſe the emiſſion of hepatic air cauſes an impurity in the reſidue, and in the latter there is not only an emiſſion of inflammable air, but likewiſe a formation of volatile alkali by the combination of the inflammable air in the naſcent ſtate with part of the phlogiſticated air. The air bladder of the carp contains phlogiſticated air of conſiderable purity; but this can be obtained only at certain ſeaſons when the fiſh are in

plenty. The pureſt phlogiſticated air is ſaid to be that which is obtained by cauſing the dephlogiſticated or acrated marine acid, as it is diſengaged in the aerial form, to be received in a bottle containing the moſt pure volatile alkali. In this caſe the volatile alkali is decompoſed; its inflammable air combines with the vital air of the marine acid, while its phlogiſticated air is emitted.

The excellent Berthollet, in his enquiries into the nature of animal ſubſtances, found that phlogiſticated air, or its baſe, compoſes a large proportion of their maſſes. He draws this inference from the conſideration, that it is diſengaged in large quantities by the application of a weak nitrous acid at a moderate temperature (ſee page 40). M. de Fourcroy * has repeated, and extended theſe experiments, and finds,

1. That azote (phlogiſticated air), or its baſis, is ſo abundant in animal matters, that the weakeſt nitrous acid, aſſiſted by a ſlight elevation of temperature, is ſufficient to diſengage it. The heat of the atmoſphere, when it exceeds ſeventy degrees, is ſufficient for the purpoſe. But when a greater heat is applied by art, the diſengagement is interrupted by an abſorption, which requires the experiment to be made with caution.

2. The quantity of phlogiſticated air is not the ſame from different animal parts. Gelatinous ſubſtances afford the leaſt; next to theſe the aluminous matter which hardens and becomes opake by heat, ſuch as the white of egg. Serum of blood, cheeſe, and the like, afford a larger quantity. And moſt of all the concreſcible fibrous matter, ſuch as the clot of the blood, and the greater part of the muſcles, affords the largeſt quantity of phlogiſticated air.

3. The fleſh of young animals affords leſs than that of old. But the difference is not conſiderable between frugivorous and carnivorous animals, or between fiſhes and quadrupeds, except that the latter appear to afford it more readily; a circumſtance from which this chemiſt ſuppoſes the greater promptitude of fiſhes to putrefy may ariſe.

4. The nitrous acid requires as much alkali to ſaturate it after it has ſerved this proceſs as before. If the product of true nitre were equal in both caſes, this circumſtance would incontrovertibly prove, that the phlogiſticated air came from the animal ſubſtance, and not from the nitre: but in the ſaturation of nitrous acid the quantity of alkali will differ accordingly as the acid itſelf is more or leſs fuming or phlogiſticated.

5. The proportion of phlogiſticated air afforded by various animal ſubſtances in this way is in proportion to the volatile alkali they reſpectively afford by diſtillation; and ſuch bodies as, by ſpontaneous change or putrefaction, have become in part converted into volatile alkali, do not afford any phlogiſticated air.

Phlogiſticated air is leſs heavy than common air. It ſuddenly extinguiſhes flame, and very quickly and inevitably deſtroys animal life. If it be mixed with vital air in the proportion of about 72 parts to 28 of the vital air, it forms a fluid not perceptibly differing from the air of the atmoſphere. No evident effect takes place between phlogiſticated air and water, or earthy ſubſtances. Nitrous acid abſorbs a portion of it, and is rendered fuming. Delicate blue colours are ſlightly reddened by this air. Its ſmell is peculiar and unpleaſant. Agitation in water and the effects of vegetation have been found to render it more reſpirable than before. But theſe facts do not appear to be any proof that it contains vital air; for it is well known that any air agitated in a tub of water becomes gradually mixed with the air of the atmoſphere; and when plants vegetate in phlogiſticated air, and render it leſs

* Annales de Chimie, I. 40.

noxious,

noxious, it is moſt probable that this effect ariſes from the vital air which plants are known to emit in certain circumſtances during life, together with the abſorption of part of the phlogiſticated air which they imbibe.

AIR, PHOSPHORIC. The phoſphoric acid reſembles denſe vitriolic acid, in the difficulty with which it aſſumes the vaporous form, and the readineſs of its ſubſequent condenſation. Dr. Prieſtley's attempts to obtain it in the aerial form, by treating it with mercury and with ardent ſpirits, were ineffectual; and though it acted upon iron, yet the aerial produce was inflammable, which the Doctor does not ſeem to think of a phoſphoric nature.

Phoſphorus however, which in ſo many particulars reſembles ſulphur, is likewiſe capable of affording a permanently elaſtic fluid of the hepatic kind, when it is heated with alkali *. Ten or twelve grains of phoſphorus were mixed with about half an ounce of cauſtic fixed alkaline ſolution in a very ſmall phial, furniſhed with a bended tube, and the air was received over mercury. Upon the firſt application of heat, two ſmall exploſions took place attended with a yellow flame and white ſmoke, which penetrated through the mercury into the receiver; theſe were followed by an equable production of air. At laſt the phoſphorus began to ſwell and froth; and the rupture of the phial being feared, the tube was ſtopped to prevent the acceſs of atmoſpheric air. But while diſpoſition was making to diſengage the phial and tube from the apparatus, and throw it into a water tub, it burſt with a loud exploſion, by reaſon of ſome obſtruction in the tube, and a fierce flame immediately iſſued from it. The quantity of air obtained was however about 8 cubic inches.

This air was diminiſhed very ſlightly by agitation with an equal bulk of water, and then became cloudy like white ſmoke, but ſoon afterwards recovered its tranſparency. Upon turning up the mouth of the tube to examine the water, the unabſorbed air inſtantly took fire, and burned with a yellow flame without exploding, leaving a reddiſh depoſit on the ſides of the tube. The temperature was 68°.

Water impregnated with phoſphoric air, and over which this air had burned, ſlightly reddened tincture of litmus, and did not affect Pruſſian alkali: but water impregnated with this air, without ſuffering the air to burn over it, ſcarcely affected litmus.

To a meaſure of phoſphoric air, Mr. Kirwan let up a meaſure of water, and through this ſome ſmall bubbles of common air; every bubble flamed, and produced a white ſmoke, until about half as much common air was introduced as there was originally of phoſphoric; and yet the original bulk did not ſeem to be increaſed. The flame each time produced a ſmall commotion, and a ſmoke deſcended after inflammation into the water: when flame ceaſed to be produced, ſmoke ſtill followed the introduction of more air. Bubbles of phoſphoric air, eſcaping through mercury into the atmoſphere, flame, crackle, and ſmell exactly like the electric ſpark.

Nitrous air produced a very ſlight diminution with a white ſmoke in phoſphoric air; alkaline air ſcarcely at all diminiſhed it; fixed air produced a white ſmoke, ſome diminution, and a yellow depoſit.

Phoſphoric air is ſpeedily deſtructive of animal life. The difference between this air and ſulphureous hepatic air, appears very nearly to follow the greater combuſtibility and volatility of the phoſphorus; and as far as their reſpective properties are known, their theories are much the ſame. Some chemiſts conſider phoſphoric air as nothing but phoſphorus in the aerial ſtate; but moſt of the antiphlogiſtian philoſophers admit it to conſiſt of a ſolution of phoſphorus in inflammable air, afforded by the decompoſition of water.

AIR OF SPARRY FLUOR. *See* ACID OF FLUOR.

* Kirwan in Phil. Tranſ. for 1785.

AIR, VITAL, *or* DEPHLOGISTICATED. This aerial fluid being the grand inſtrument of combuſtion, taken in the moſt extended ſenſe, has ſo conſiderable a ſhare in moſt of the operations of chemiſtry, that there are few of the articles of the preſent work which do not tend to explain and elucidate its properties. It compoſes between one third and one fourth of the weight of the air of the atmoſphere, and is abſorbed by various bodies, from which it may afterwards be extricated or expelled by heat aſſiſted by the action of light. *See* AIR, ATMOSPHERICAL.

It may be obtained by heat, from mercury calcined without addition; from red precipitate, and other mercurial calces; from minium; from manganeſe, and other metallic calces; from moſt nitrous and vitriolic ſalts. It is alſo contained in the bladders of ſea weed, and in waters. The green vegetable matter formed in water emits it by the action of light; and it is found in general that the green leaves of plants, expoſed to the action of light, emit vital air. Moſt of the vital air thus obtained is accompanied by an admixture of phlogiſticated air. The pureſt is that from precipitate per ſe newly made, or preſerved in cloſe veſſels; or from manganeſe; or from the leaves of plants.

Vital air is ſomewhat heavier than the common air of the atmoſphere, and maintains combuſtion longer in proportion to its purity. The combuſtion by this fluid is aſtoniſhingly intenſe, and appears, when urged by the blow-pipe in a ſtream upon a ſmall portion of ignited matter, to equal or exceed the powers of the ſtrongeſt burning lenſes or mirrors. We have no account of experiments yet made with both in combination; though there is no doubt but that they would prove highly intereſting. The teſt of nitrous air, and every other fact in which this air is concerned, indicate its ſuperior efficacy or purity, with regard to combuſtion and the maintenance of animal life. *See* ACID, NITROUS.

Vital air being abſorbed or transferred in thoſe combuſtions in which acids are produced, it is univerſally admitted as the chief cauſe of acidity in bodies: that is to ſay, acids are combuſtible bodies united with vital air, and deprived of phlogiſton, according to the theory of chemiſtry which admits that principle. See the general article ACIDS; and alſo the ſeveral ACIDS reſpectively.

Moſt of the heat in combuſtion is taken to ariſe from the condenſation and change of capacity of vital air, when it paſſes from the elaſtic to the denſe fluid or ſolid ſtate. *See* COMBUSTION and HEAT. Heat is, however, produced very frequently by the mere tranſition of vital air from one combination to another: as, for example, when gun-powder is fired, the vital air of the nitre is tranſmitted to the charcoal. In ſuch caſes the change of capacity may not be always in the vital air, though it ſeems probable.

Whether vital air in all caſes produces an acid by combination in due proportion with combuſtible matter, has not been yet aſcertained. There being no other combuſtible bodies than metals, acid baſes and inflammable air; and ſeveral metals being acidifiable; there ſeems to be little queſtion, except concerning inflammable air. When this is burned with vital air, there is a production of water with nitrous acid and fixed air. Whether the water be formed by the union of vital and inflammable air, and the two acids which accompany it be merely the reſult of caſual impurity; or whether the two airs be employed in forming theſe acids, while the water is merely depoſited, which was before ſuſpended during the permanently elaſtic ſtate of the airs; are ſubjects of controverſy which at preſent divide ſome of the moſt eminent chemical philoſophers. *See* WATER.

Vital air changes the colours of vegetable and animal ſubſtances. It is this principle which is the chief agent in bleaching of cloth, and in the hardening of wax. *See* BLEACHING.

AIR,

AIR, VITRIOLIC. When the vitriolic acid is dephlogiſticated, or deprived of part of the due proportion of vital air required to conſtitute the moſt perfect ſtate of acidity, it becomes volatile, and readily aſſumes the aerial form. For the various properties and habitudes of the acid in this ſtate, *ſee* ACID, VITRIOLIC, page 66.

ALABASTER. Among the ſtones which are known by the name of marble, and have been diſtinguiſhed by a conſiderable variety of denominations by ſtatuaries, and others whoſe attention is more directed to their external characters and appearance than their component parts, alabaſters are thoſe which have a greater or leſs degree of imperfect tranſparency, a granular texture, are ſofter, take a duller poliſh than marble, and are uſually of a white colour. Some ſtones, however, of a veined and coloured appearance, have been conſidered as alabaſters, from their poſſeſſing the firſt mentioned criterion; and ſome tranſparent and yellow ſparry ſtones have alſo received this appellation.

Chemiſts are at preſent agreed in applying this name only to ſuch opake, conſiſtent and ſemi-tranſparent ſtones as are compoſed of lime united with the vitriolic acid. But the term is much more frequent among maſons and ſtatuaries than chemiſts. Chemiſts in general confound the alabaſters among the ſelenites, gypſums, or plaſter of Paris, more eſpecially when they allude only to the component parts, without having occaſion to conſider the external appearance, in which only thoſe ſeveral compounds differ from each other.

As the ſemi-opake appearance and granular texture ariſes merely from a diſturbed or ſucceſſive cryſtallization, which would elſe have formed tranſparent ſpars, it is accordingly found that the calcareous ſtalactites, or drop-ſtones, formed by the tranſition of water through the roofs of caverns in a calcareous ſoil, do not differ in appearance from the alabaſter, moſt of which is alſo formed in this manner. But the calcareous ſtalactites here ſpoken of conſiſts of calcareous earth and fixed air; while the alabaſter of the chemiſts is formed of the ſame earth and vitriolic acid, as has already been remarked.

ALBUM GRÆCUM. Innumerable are the inſtances of fanciful ſpeculation, and abſurd credulity, in the invention and application of ſubjects in the more ancient materia medica. The white and ſolid excrement of dogs, which ſubſiſt chiefly on bones, has been received as a remedy in the medical art, under the name of Album Græcum. It conſiſts, for the moſt part, of the earth of bones, or lime in combination with phoſphoric acid.

ALCHEMY. The practice of chemiſtry, comprehending every operation which is not mechanical, muſt of courſe have been among the earlieſt conſequences of thoſe efforts of the human mind which ſupply our wants, and diſtinguiſh civilized nations from the uncultivated. The various arts dependant upon this ſcience were practiſed for ages before the ſyſtematic reaſoning and inferences of philoſophers had traced its dependances, and formed the ſcience itſelf. Immediate profit is the object of purſuit in thoſe who practiſe the arts; and while the ſeveral branches of chemical operation continued to be mere arts, their profeſſors or practiſers had in general no other views. It could not but happen, however, but that men of abilities would be found among theſe profeſſors, who would reaſon well or ill upon what they ſaw; and as all reaſoning with regard to natural appearances conſiſts chiefly in the claſſing of ſimilar phenomena, and deducing other events from them by analogy, it would follow of courſe that theſe men would diſcover rules, and eſtabliſh general obſervations, by means of which their operations would be facilitated and extended. The ſpirit of trade would nevertheleſs intermix itſelf with their ſpeculations, and lead them to conſider their diſcoveries as lucrative ſecrets, not to be communicated but to others

of

of the ſame profeſſion, whoſe ſucceſsful reſearches had enabled them to afford other ſecrets in return. Thus it was that philoſophical chemiſtry had its birth: in its infancy it was alchemy, a ſcience whoſe profeſſors were tradeſmen, dazzled at the fruitful and extenſive conſequences to which their reſearches ſeemed to lead; looking down upon and deſpiſing the common operator, who poſſeſſed no clue to lead him beyond the ordinary courſe of his buſineſs; and extolling their own knowledge, which, from vanity as well as motives of profit, they either kept to themſelves, or communicated in myſterious and enigmatical writings. The earlieſt philoſophical writers on chemiſtry were alchemiſts, and diſtinguiſhed themſelves from common chemiſts by this appellation. As the true methods of philoſophizing became better known, and liberality of ſentiment increaſed, chemiſtry became a ſcience in the hands of men of better taſte and more enlightened judgment. The writings of the alchemiſts and their elevated profeſſions continued notwithſtanding to have their effects upon many perſons, and are not entirely without their influence at the preſent inſtant. The efficacy of chemical preparations for medical uſe proved ſufficient for a long time to enforce a certain degree of credit in favour of a panacea, or univerſal medicine, powerful to cure all diſeaſes; and a number of facts ill underſtood, and taken as the ground of extenſive and plauſible inferences, have induced numbers to believe that metals might be tranſmuted into each other. This laſt operation was chiefly aimed at the tranſmutation of metals of inferior price into gold. The pretence is ſtill uſed by artful perſons to impoſe on the ignorant, and in ſome inſtances, perhaps, by the ignorant, who impoſe on themſelves.

ALCOHOL, *or* ALKOHOL. The pureſt ardent ſpirit, which contains leſs water than any other, is frequently called by this name.

ALEMBIC, *or* STILL. This part of chemical apparatus, uſed for diſtilling or ſeparating volatile products by firſt raiſing them by heat, and then condenſing them into the liquid ſtate by cold, is of extenſive uſe in a variety of operations. It is deſcribed under the article APPARATUS, which ſee.

ALEMBROTH SALT. Corroſive ſublimate is rendered much more ſoluble in water by the addition of ſal ammoniac. From this ſolution cryſtals are ſeparated by cooling, which were called ſal alembroth by the earlier chemiſts, and appear to conſiſt of volatile alkali, marine acid, and mercury; but in what ſtate the marine acid may be, whether the common or dephlogiſticated, does not ſeem to have been aſcertained.

ALGAROTH, POWDER OF. Among the numerous preparations which the alchemical reſearches into the nature of antimony have afforded, the powder of algaroth is one. When butter of antimony is thrown into water, it is not totally diſſolved; but part of the metallic calx falls down in the form of a white powder, which is the powder of algaroth. It is violently purgative, and emetic in ſmall doſes of three or four grains. *See* ANTIMONY, *and* BUTTER OF ANTIMONY.

ALKAHEST. The pretended univerſal ſolvent, or menſtruum, of the ancient chemiſts. Kunckel has very well ſhewn the abſurdity of ſearching for an univerſal ſolvent, by aſking, "If it diſſolves all ſubſtances, in what veſſels can it be contained?"

ALKALI. Modern chemiſtry has diſcovered many acids, and has ſucceeded in decompoſing them into ſimpler ſubſtances, and recompoſing them. But the alkalis ſtill remain in number only three; and nothing has yet been effected to ſhew an unequivocal decompoſition of the two fixed alkalis. The general characters in which the three alkalis agree are the following:

1. They have a peculiar taſte, which is diſagreeably cauſtic, even when diluted with water.

water. 2. They change blue vegetable colours to a green. 3. They have a very ſtrong attraction for water, with which they unite in all proportions, and even attract it in ſufficient quantities from the atmoſphere to become fluid. 4. They combine with acids in the humid way, by a ſtronger affinity than is poſſeſſed in general by any other ſubſtances. 5. They melt in a moderate heat, and in a ſtronger heat they are volatilized. 6. In the dry way, they diſſolve all earths and metallic calces.

The volatile alkali poſſeſſes the above general properties, except ſo far as its diſpoſition to riſe in the aeriform ſtate at an heat leſs than boiling water, prevents its being exhibited in the dry way. Its affinities are alſo leſs ſtrong.

Alkalis which contain fixed air are called mild alkalis.

The uſual teſts of alkalis are the tincture of turnſole, called litmus by the dyers, and the ſyrup of violets. But the knowledge of the habitudes of theſe bodies, like all others, can be but very imperfectly exhibited by general notions; becauſe every one of the combinations into which they enter, does in fact exhibit ſome diſtinct elective attraction or property.

ALKALI, FIXED VEGETABLE. The vegetable alkali is found in ſome ſalts, which may be ſaid to be of the mineral kingdom; but it is obtained for all the purpoſes of trade and ſcience from vegetable matters. Of this there are ſeveral kinds, which differ only in the reſpective quantities, and nature of the impurities they contain. The cendres gravelées is a ſtrong alkali made by burning the huſks of grapes and wine lees. Potaſh is prepared by lixiviating wood aſhes, and is very far from being pure. Moſt vegetables afford this alkali by burning them, and mixing their aſhes with pure water, which after decantation or filtering may be evaporated, and will leave the ſalt behind. The pureſt is obtained by wrapping tartar in wetted brown paper, and placing the parcels in beds or ſtrata alternately with charcoal in a furnace. The whole is then to be ſet on fire, and the fire continued till the blackening ſmoke ceaſes to ariſe. If the heat be too intenſe, the alkali will melt and mix with the impurities of the coal; but when the proceſs is well conducted, the parcels may be taken out entire. By lixiviation or ſolution in pure water, with ſubſequent filtration, evaporation, dying, and calcining in a low heat, the alkali is obtained very white, and contains a conſiderable portion of fixed air. This might be driven off by heat; but ſuch an increaſe of temperature would cauſe the alkali to diſſolve the earth of the veſſel, for which reaſon other methods are uſed. The vegetable alkali is known in the ſhops by the name of ſalt of tartar; but moſt chemiſts in London ſell the impure alkali of potaſh by this name.

It is not eaſy to purify the common vegetable alkalis met with in trade; and it is indeed ſeldom attempted. Neither is there any neceſſity in moſt operations that the chemiſt ſhould employ his labour in procuring the alkalis abſolutely diſengaged from all other matter, as they will be equally uſeful if kept in combination, either with fixed air or with water; in which ſtates the quantities may be more accurately aſcertained by weight or meaſure when uſed, than if pure; becauſe their rapid attraction for water in the latter caſe renders it almoſt impracticable to weigh them.

One of the readieſt methods of obtaining the vegetable alkali in a ſtate of conſiderable purity, conſiſts in detonating common nitre in a crucible with charcoal. This ſalt conſiſts of the vegetable alkali united with nitrous acid. If the fineſt priſmatic nitre be fuſed, and made red hot in a crucible, and charcoal be then added by degrees, a moſt intenſe combuſtion takes place; during which the acid principle of the ſalt is diſſipated, and the alkali is left in combination with fixed air only: that is to ſay, the vital air of the acid forms fixed air with the inflammable part of the charcoal

coal, moſt of which fixed air unites with the alkali, while the phlogiſticated air or other component part of the nitrous acid flies off. *See* ACID, NITROUS. More charcoal muſt be added as long as it continues to produce the vivid flame; and the heat muſt be raiſed towards the end, in order that the decompoſition of the laſt portions of the nitre may be more completely effected. This ſalt has been improperly termed fixed nitre; but there is no difference between the pure ſpecimens of this alkali, whatever ſubject it may have originally been obtained from.

To obtain the vegetable alkali in a ſtate of great purity, the alkali of nitre by preference, or any other vegetable alkali, muſt be boiled for a ſhort time with about twelve times its weight of water, and half its weight of quicklime, in a clean iron veſſel. This lixivium muſt be filtered through paper ſupported by a cloth. If the clear fluid occaſions no precipitation from lime-water, it is deprived of fixed air; but if not, it muſt be again boiled with the ſame quantity of quicklime, and filtered a ſecond time. The clear liquor muſt then be expoſed to evaporation in a retort, or long-necked veſſel, in order that the emiſſion of the ſteam may prevent the contact of the external air, from which the alkali would abſorb a portion of fixed air, if the veſſel were quite open or wide mouthed. The ſalt which remains conſiſts, for the moſt part, of the vegetable alkali in a pure or cauſtic ſtate, contaminated however with ſome other neutral ſalts, afforded in ſmall quantities by the charcoal uſed in the detonation of the nitre, or by the principles of the vegetable ſubſtances made uſe of in obtaining the alkali, if nitre had not been uſed in the operation. To ſeparate the pure alkali from theſe ſalts, a conſiderable quantity of ardent ſpirit muſt be added, which diſſolves it totally. The decanted ſpirituous ſolution may in like manner be evaporated by diſtillation in a retort, and the ſalt left in a dry ſtate. But as there are few occaſions in which the ſalt may be wanted in this ſtate, it may be diſſolved in a ſmall quantity of very pure water, and muſt be preſerved in well cloſed veſſels made of good glaſs. Several of the ſofter kinds of glaſs are ſo far altered by the action of very pure alkalis, that they crack and ſplit in a variety of directions.

The ordinary vegetable alkali, whether obtained from tartar, or from nitre, is not ſaturated with fixed air, and deliquiates in the air. In this way, it attracts about three times its weight of water. The ſtrong ſolution of this alkali is uſually called oil of tartar per deliquium. Its action on the ſkin converts it into a kind of ſope, which produces a ſenſation or feel of greaſineſs between the fingers, and has given riſe to this appellation. But if it be expoſed a ſufficient time to the atmoſphere, it abſorbs a much larger quantity of fixed air, which neutralizes it, and in this ſtate it may be obtained in permanent cryſtals. *See* AIR, FIXED.

A moderate red heat keeps the vegetable alkali in fuſion with very little loſs of quantity. A more violent fire, ſuch as that of a ſmith's forge, or a wind furnace, volatilizes it, and even entirely diſſipates the whole. No one has yet made the experiment of diſtilling or ſubliming the fixed alkali in a ſtrong heat, ſo as to determine what change it may undergo in that proceſs, if any. The vegetable alkali, when liquefied by heat, is a very powerful ſolvent. With earthy ſubſtances it forms glaſs. Metals are not diſſolved by it, but their calces readily unite with it. When the alkali is fuſed with any earth nearly in equal proportions, or ſtill leſs of the alkali, it forms a combination which when cold is tranſparent, and reſiſts the action of moſt ſolvents at a moderate temperature. This is the well-known compoſition called glaſs. *See* GLASS. When the alkali in fuſion is three or four times the weight of the earth it may diſſolve, the ſaline properties prevail, and the compound is ſoluble in

water. Siliceous earth, thus ſuſpended in water by the medium of an alkali, is called the liquor of flints.

The vegetable fixed alkali unites with great energy to acids. With the vitriolic acid it forms the cryſtallizable ſalt called vitriolated tartar; with the nitrous acid it affords the common priſmatic nitre; and with the marine acid it produces a ſalt which is known by the name of the ſalt of ſylvius, or, improperly, regenerated ſea ſalt. The other acids likewiſe afford peculiar combinations with this alkali, which are mentioned under their reſpective titles.

The fixed vegetable alkali alſo combines with inflammable ſubſtances. With ſulphur, either in the humid or dry way, it forms liver of ſulphur. With phoſphorus it forms a peculiar hepatic compound. With oils it forms SOAP [which ſee]. It ſcarcely acts upon metallic ſubſtances in the dry way, unleſs calcined; and in the humid way, calcination ſeems likewiſe to be neceſſary for this purpoſe, either by the previous action of acids, or by the preſence of vital air afforded by the atmoſphere.

A conſiderable number of ſpeculations have been entered into reſpecting the origin of the fixed alkalis. The vegetable alkali being moſtly obtained by the incineration of plants or vegetable products, has been ſuppoſed to owe its formation to the fire. This however has never been proved; for the alkali afforded by tartar when burned is not greater in quantity than the ſame tartar affords when diſſolved in water, and left to putrefy or ſuffer a ſpontaneous decompoſition of its acid in an open veſſel for many months. The ſalt of ſorrel, the common nitre obtained from ſeveral plants, and vitriolated tartar, and even nitre found in the mineral kingdom, not to mention other inſtances, likewiſe exhibit this alkali in ſituations where it ſeems by no means to have undergone the proceſs of incineration. It has been remarked, however, that in all the circumſtances in which fixed alkali is afforded, there has been a previous expoſure to vital air and phlogiſticated air, and upon grounds little better than theſe it has been conjectured that the alkalis may conſiſt of certain ſubſtances combined with vital, or perhaps with phlogiſticated air. On the firſt of theſe ſuppoſitions, we ſhould take alkalis to be bodies ſo eminently combuſtible, as to retain vital air by an attraction too ſtrong to be overcome by any means we are acquainted with, and conſequently not decompoſable by art. And this eminent degree of combuſtibility would afford a reaſon for their ſtrong attraction to acids, all of which contain vital air, and in particular to the dephlogiſticated marine acid, upon which they act in ſo peculiar a manner as to deprive it of the ſurplus of vital air it contains; inſomuch that the ſalt formed on this occaſion contains alkali, marine acid, and a much larger proportion of vital air, than the marine acid itſelf was capable of combining with; while the remaining portion of the aerated acid which afforded the vital air becomes converted into common marine acid, forming ſalt of ſylvius with another portion of the alkali.

On the other hand, the knowledge we have acquired of the component parts of volatile alkali, which are phlogiſticated and inflammable air, have led ſome chemiſts to conſider phlogiſticated air as the principle of alkalinity, in the ſame manner as vital air is taken to be the principle of acidity. This conjecture does not indeed ſo readily exhibit any analogy to explain the mutual action of alkalis and acids; but if the baſes of fixed alkalis conſiſt of either lime, magneſia, ponderous or even argillaceous earth, the known attraction of theſe ſubſtances for acids will be ſufficient to account for the attraction exhibited by alkalis.

ALKALI, MINERAL. This fixed alkali, which is known in commerce by the name of barilla when in a leſs pure ſtate, and by that of ſalt of ſoda when in clean cryſtals, is found in immenſe quantities in the mineral kingdom in combination with the marine acid, with which it forms ſea ſalt; and likewiſe, though leſs plen-

tifully, in combination with the vitriolic acid in the form of Glauber's ſalt. As chemiſtry has not, however, invented any method ſufficiently cheap to decompoſe theſe ſaline ſubſtances, the ſoda of commerce is principally obtained by the incineration of plants which grow on the ſea ſhore, and lixiviation of their aſhes, in the ſame manner as the fixed vegetable alkali is obtained from plants in general. It is found native on the ground in the iſland of Teneriffe, and elſewhere.

The mineral alkali in its ordinary ſtate is ſo far neutralized by fixed air, that it cryſtallizes, and is ſo far from deliqueſcing by expoſure to the atmoſphere, that it even loſes its water of cryſtallization, and falls into a dry powder. But when it is deprived of fixed air, it attracts moiſture like the vegetable alkali, and cannot indeed be diſtinguiſhed from that ſubſtance by any of its more obvious properties, though its habitudes with other ſubſtances, and the compounds it forms with them, are very different from thoſe produced by the other fixed alkali.

The habitudes of mineral alkali in the fire are nearly the ſame as thoſe of the vegetable. It diſſolves earthy ſubſtances and metallic calces; and the glaſs it forms is ſaid to be more ſolid and leſs alterable than that into which the vegetable alkali enters. Mineral alkali unites very powerfully with acids, though by a leſs affinity than that of the vegetable alkali, and the ſalts it forms differ very conſiderably from all others. With the vitriolic acid it forms Glauber's ſalt, as we have already taken notice; with the nitrous acid it forms quadrangular nitre, a ſalt that conſiderably reſembles the common or priſmatic nitre in its properties, and with the marine acid it produces the common ſea ſalt. With the other acids it forms various combinations, which are deſcribed under their reſpective heads. This alkali likewiſe combines with inflammable ſubſtances, and forms a harder kind of ſoap with oils than is obtained by uſing the vegetable alkali.

The decompoſition of common ſalt, for the purpoſe of obtaining the mineral alkali in great plenty and at a cheap rate, has been attempted by a great number of chemiſts. The moſt ſucceſsful proceſs is that of Scheele, who deprives it of its acid by the calx of lead or litharge. If a quantity of this calx be mixed with half its weight of common ſalt, then triturated with water till it aſſumes a white colour, and left to ſtand ſome hours, a decompoſition enſues, the acid uniting with the metallic calx, and the alkali remaining diſengaged. In this way, however, the alkali is not of ſufficient value to pay the charges, and therefore the proceſs is carried on to no greater extent than is required by the demand for the combination of lead and marine acid, which after it has been duly heated forms a fine greeniſh-yellow pigment.

Very little can be ſaid from experiment concerning the intimate compoſition of the mineral alkali; and the conjectural inferences reſpecting this ſalt are nearly the ſame as thoſe which have been ſlightly mentioned in the preceding article. It has been conjectured that lime is the baſis of vegetable alkali, and magneſia of the mineral.

ALKALI, PHLOGISTICATED, *or* PRUSSIAN. When a fixed alkali is ignited with bullock's blood, or other animal ſubſtances, and lixiviated, it is found to be in a great meaſure ſaturated with the Pruſſian acid. From the theories formerly adopted reſpecting this combination, it has been diſtinguiſhed by the name of phlogiſticated alkali. The alkali cannot be conveniently ſaturated with the colouring matter, or Pruſſian acid, in any other way than by boiling it with Pruſſian blue. For a detail of its properties, *ſee* ACID OF PRUSSIAN BLUE; and alſo PRUSSIAN BLUE.

ALKALI, VOLATILE. The volatile alkali differs remarkably from the other two alkalis in its diſpoſition to aſſume the aeriform ſtate, and to riſe by a moderate heat, even when combined with other ſubſtances. Its peculiar and pungent ſmell affords a diſtinctive criterion of its preſence and diſengagement. It is met with in the ſhops, either in a concrete form in combination with fixed air, in which ſtate it is

uſually called ſal volatile, or improperly volatile ſal ammoniac, or elſe in the fluid ſtate combined with water, when it is uſually diſtinguiſhed by the appellation of ſpirit of ſal ammoniac with lime, no doubt, becauſe it is obtained by diſtilling thoſe two ſubſtances together.

The volatile alkali is obtained during the deſtructive diſtillation of all animal ſubſtances which have not ſuffered putrefaction or ſpontaneous decompoſition, and alſo from plants which are chiefly of the cruciform kind. Putrefaction likewiſe diſengages it from theſe ſubſtances. It is found that all thoſe bodies which afford volatile alkali by diſtillation do likewiſe afford phlogiſticated air when treated with weak nitrous acid, and that the reſidue, thus deprived of its phlogiſticated air, affords no volatile alkali, or much leſs than before; a circumſtance which, among others, ſerves to indicate the compoſition of the volatile alkali, and that it does not exiſt ready formed in theſe ſubſtances, but is produced by the action of heat or putrefaction, which cauſes the phlogiſticated air to unite with the inflammable air that plentifully exiſts in bodies of this kind. *See* AIR, PHLOGISTICATED.

The volatile alkali obtained by diſtillation from animal ſubſtances is contaminated with coaly matter and oil, and therefore in its firſt ſtate poſſeſſes various properties, according to the nature of its impurities. Theſe may be removed in various ways, but by none better than the addition of marine acid, which converts it into ſal ammoniac.

Moſt of the volatile alkali is obtained from ſal ammoniac. This ſalt was formerly imported from Egypt, where it is procured by ſublimation from ſoot produced by burning the dung of camels. But it is now made in great plenty in Britain for the purpoſe of commerce. The volatile alkali is obtained in an impure liquid ſtate by the manufacturers, who diſtil it from bones or ſoot, or any other ſubſtance that affords it. To this they add the mother water of vitriol; and alſo common ſalt in due quantities. The vitriolic acid firſt combines with the volatile alkali; but when the common ſalt, which conſiſts of fixed mineral alkali and marine acid, is added, a change of the principles takes place by double elective attraction. The vitriolic acid ſeizes the mineral alkali, and forms the new compound, known by the name of Glauber's ſalt; while the marine acid unites with the volatile alkali, and forms ſal ammoniac. By evaporation of the water, theſe ſalts are ſeparated by cryſtallization, and the ſal ammoniac is ſublimed into cakes for ſale.

In order to diſengage the volatile alkali from ſal ammoniac by diſtillation, it is neceſſary to add ſome fixed ſubſtance, which ſhall combine with and prevent the marine acid from riſing. Chalk and ſlaked lime are the bodies commonly uſed. If a mixture of two parts of chalk and one of ſal ammoniac in powder be expoſed to a ſand heat in a retort, with a receiver adapted, a change of principles by double affinity takes place. The chalk, which conſiſts of lime and fixed air, is decompoſed, and alſo the ſal ammoniac. The lime unites with the marine acid, and forms a fixed earthy ſalt, which remains in the retort; and the fixed air unites with the volatile alkali, and paſſes into the receiver, where it appears in the form of a white hard ſalt of a pungent ſmell. This is the mild volatile alkali, or ſal volatile of the apothecaries and perfumers. It is well known as a ſtimulant uſually put into ſmelling bottles.

When lime or calcareous earth, deprived of fixed air, is made uſe of, the decompoſition takes place as before; but the alkali riſes in the form of alkaline air, and no part of the volatile product is condenſed, until the water which may have been contained in the ſal ammoniac or in the lime comes over. This water abſorbs a quantity of the air, and forms the pure or cauſtic volatile alkali; but not, however,

before a conſiderable quantity of the alkaline air has been loſt. Intelligent operators at preſent avoid this loſs, by availing themſelves of an apparatus of the ſame kind as is exhibited in figure 2, by the help of which the alkaline air being obliged to preſs in contact with water in the receivers, is for the moſt part abſorbed.

The volatile alkali has a much leſs ſtrength of attraction in its combination than the fixed alkalis, and it is formed and decompoſed in a variety of chemical operations. It unites very readily with acids, and forms ſalts which have been diſtinguiſhed by the name of ammoniacal ſalts, and are noticed under their reſpective acids. It combines with oils, and much more readily with the eſſential than with the fixed oils. Spirit of wine diſſolves it, as it does likewiſe its ſaponaceous compounds; but theſe compounds, though miſcible with water, are ſcarcely ſoluble in that fluid. *See* EAU DE LUCE. Sulphur and phoſphorus are acted upon by this alkali, though feebly. A ſulphureous volatile hepar is produced by the union of this alkali in the aerial ſtate, with ſulphur in the vaporous ſtate. If equal parts of quicklime and ſal ammoniac be mixed together with half a part of ſulphur, and diſtilled with the pneumatic apparatus (fig. 2) with a ſmall quantity of water in the receiver, a reddiſh yellow hepatic liquor will be obtained, which is the volatile hepar, and was formerly known by the name of the fuming liquor of Boyle, ſo called from its inventor, and from the white fumes it emits in the air.

The volatile alkali combines with many of the metallic ſubſtances, though probably, in all caſes, previous calcination, or the preſence of vital air, may be neceſſary for this effect. Metallic precipitates thrown down by volatile alkali are moſtly rediſſolved if an exceſs of alkali be added. For the habitudes of volatile alkali with metallic ſubſtances, *ſee* the Metals reſpectively.

The component parts of volatile alkali are phlogiſticated air and inflammable air, in the proportions of ſix parts, by weight, of the former to one of the latter. On this ſubject conſult AIR, ALKALINE; and alſo ACID, NITROUS, page 34.

ALKANET. The alkanet plant is a kind of bugloſs, which is a native of the warmer parts of Europe, and cultivated in ſome of our gardens. The greateſt quantities are raiſed in Germany and France, particularly about Montpelier, from whence we are chiefly ſupplied with the roots. Theſe are of a ſuperior quality to ſuch as are raiſed in England. This root imparts an elegant deep red colour to pure ſpirit of wine, to oils, to wax, and to all unctuous ſubſtances. The aqueous tincture is of a dull browniſh colour; as is likewiſe the ſpirituous tincture when inſpiſſated to the conſiſtence of an extract. The principal uſe of alkanet root is, that of colouring oils, unguents, and lip-ſalves. Wax tinged with it, and applied on warm marble, ſtains it of a fleſh colour, which ſinks deep into the ſtone; as the ſpirituous tincture gives it a deep red ſtain.

As the colour of this root is confined to the bark, and the ſmall roots have more bark in proportion to their bulk than the great ones, theſe alſo afford moſt colour.

ALLAY, *or* ALLOY. Where any precious metal is mixed with another of leſs value, the aſſayers call the latter the alloy, and do not in general conſider it in any other point of view than as debaſing or diminiſhing the value of the precious metal. Philoſophical chemiſts have availed themſelves of this term to diſtinguiſh all metallic compounds in general. Thus braſs is called an alloy of copper and zinc; bell-metal an alloy of copper and tin.

ALMONDS. Almonds conſiſt chiefly of an oil of the nature of fat oils, together with farinaceous matter. The oil is ſo plentiful, and ſo looſely combined or mixed with the other principles, that it is obtained by ſimple preſſure, and part of it may

be ſqueezed out with the fingers. There are two kinds of almonds, the ſweet and bitter. The bitter almonds yield an oil as taſteleſs as that of the other, all the bitter matter remaining in the cake after the expreſſion. Great part of the bitter matter diſſolves by digeſtion, both in watery and ſpirituous liquors; and part ariſes with both in diſtillation. Bitter almonds are poiſonous to birds, and to ſome animals. A water diſtilled from them, when made of a certain degree of ſtrength, has been found from experiment to be poiſonous to brutes; and there are inſtances of cordial ſpirits impregnated with them being poiſonous to men. It ſeems, indeed, that the vegetable principle of bitterneſs in almonds and the kernels of other fruits is deſtructive to animal life when ſeparated by diſtillation from the oil and farinaceous matter. The diſtilled water from laurel leaves appears to be of this nature, and its poiſonous effects are well known.

ALOES. This is a bitter juice extracted from the leaves of a plant of the ſame name. Three ſorts of aloes are diſtinguiſhed in the ſhops, by the names of aloe ſoccotrina, aloe hepatica, and aloe caballina. The firſt denomination, which is applied to the pureſt kind, is taken from the iſland of Zocotora; the ſecond, or next in quality, is called hepatica, from its liver colour; and the third, caballina, from the uſe of this ſpecies being confined to horſes. Theſe kinds of aloes are ſaid to differ only in purity, though, from the difference of their flavours, it is probable that they may be obtained in ſome inſtances from different ſpecies of the ſame plant. It is certain, however, that the different kinds are all prepared at Morviedro in Spain, from the ſame leaves of the common aloe. Deep inciſions are made in the leaves, from which the juice is ſuffered to flow, and this, after decantation from its ſediment, and inſpiſſation in the ſun, is expoſed to ſale in leathern bags by the name of ſoccotrine aloes. An additional quantity of juice is obtained by preſſure from the leaves, and this, when decanted from its ſediment and dried, is the hepatic aloes. And laſtly, a portion of juice is obtained by ſtrong preſſure of the leaves, and is mixed with the dregs of the two preceding kinds to form the caballine aloes. The firſt kind is ſaid to contain much leſs reſin. The principal characters of good aloes are theſe: it muſt be gloſſy, not very black, but brown; when rubbed or cut, of a yellow colour; compact, but eaſy to break; eaſily ſoluble, of an unpleaſant peculiar ſmell which cannot be deſcribed, and an extremely bitter taſte.

Aloes appears to be an intimate combination of gummy and reſinous matter, ſo well blended together, that watery or ſpirituous ſolvents, ſeparately applied, diſſolve the greateſt part of both. It is not determined whether there be any difference in the medical properties of theſe ſolutions. Both are purgative, as is likewiſe the aloes in ſubſtance; and, if uſed too freely, are apt to prove heating, and produce hemorrhoidal complaints.

ALTHEA, *or* MARSH MALLOW. Two ounces of the dry root yielded, with water, ten drams fifty grains of mucilaginous extract; and afterwards, with ſpirit, forty-one grains of reſin. The ſame quantity, treated with ſpirit, gave ſix drams of a reſinous extract, a conſiderable portion of the mucilage diſſolving in that menſtruum along with the reſin; the remainder, boiled in water, gave out five drams and forty-eight grains of pure mucilage. The inſoluble matter amounts to ſomewhat more than one fourth of the weight.

ALUDEL. The proceſs of ſublimation differs from diſtillation in the nature of its product, which inſtead of becoming condenſed in the fluid aſſumes the ſolid ſtate, and the form of the receivers may of courſe be very different. The receivers for ſublimates are of the nature of chimneys, in which the elaſtic products are condenſed and adhere to their internal ſurface. It is evident that the head of an alembic will ſerve very well to receive and condenſe ſuch ſublimates as are not very volatile

volatile. The earlier chemiſts, whoſe notions of ſimplicity were not always the moſt perfect, thought proper to uſe a number of ſimilar heads, one above the other, communicating in ſucceſſion by means of a perforation in the ſuperior part of each, which received the neck of the capital immediately above it. Theſe heads differing in no reſpect from the uſual heads of alembics, excepting in their having no noſe or beak, and in the other circumſtances here mentioned, were called aludels. They are ſeldom now to be ſeen in chemical laboratories, becauſe the operations of this art may be performed with greater ſimplicity of inſtruments, provided attention be paid to the heat and other circumſtances. *See* APPARATUS.

ALUM. This is a cryſtallizable ſalt compoſed of vitriolic acid united with argillaceous earth. It has an auſtere, ſweetiſh, and ſtrongly aſtringent taſte, which ſeems to proceed chiefly from a portion of the vitriolic acid which is neceſſary to its ſolubility in water and cryſtalline form, though it be more than requiſite to produce neutralization, as judged by the teſt of turnſole and blue paper, which it reddens. A conſiderable number of inſtances may be exhibited in chemiſtry where a ſuperabundance of one of the two principles in compound ſalts is neceſſary to produce the fineſt cryſtals, and the moſt permanent combination. *See* ACID OF TARTAR and ACID OF PHOSPHORUS. If the exceſs of acid in alum be taken away, all the taſte, the ſolubility, and the original properties of the ſalt, are loſt.

One hundred parts of cryſtallized alum require, in a mean heat, about fourteen times its weight of water to diſſolve it; but boiling water diſſolves one third more than its own weight of this ſalt, moſt of which conſequently ſeparates by cooling. If cryſtallized alum be expoſed to a gradual heat, it firſt becomes fluid by a kind of aqueous fuſion, in which its own water of cryſtallization is the principal agent; the remaining maſs, after moſt of the water has been expelled, grows opake, ſwells, foams, and at length remains quiet, ſpungy, and friable. Ignition drives off ſome of its ſuperabundant acid. The quantity of earthy baſis in alum may be determined by precipitation with fixed or volatile alkali. In this way, however, there is a ſource of inaccuracy ariſing from the inſolubility of the alum, which takes place as ſoon as its ſuperabundant acid has combined with the alkali. At this period, a portion of the neutral combination of clay and vitriolic acid falls down without further decompoſition. Long continued digeſtion in an alkaline lixivium is neceſſary to ſeparate the whole of the acid. The volatile alkali is preferable in clearing the baſe of alum, becauſe it would unite to fixed alkalis. The moſt commodious method of obtaining pure argillaceous earth conſiſts in precipitating it in this manner from alum. *See* EARTH, ARGILLACEOUS.

In this way Bergman found one hundred parts of cryſtallized alum to contain forty-four of water, eighteen of clay, and conſequently thirty-eight of vitriolic acid, and probably water, which could not be made to quit the acid.

Alum is produced, but in a very ſmall quantity, in the native ſtate; and this is mixed with heterogeneous matters. It effloreſces in various forms, upon ores during calcination, but it ſeldom occurs cryſtallized. The greater part of this ſalt is factitious, being extracted from various minerals called alum ores, ſuch as, 1. Sulphurated clay. This conſtitutes the pureſt of all aluminous ores, namely, that of la Tolfa, near Civita Vecchia, in Italy. It is white, compact, and as hard as indurated clay; from whence it is called petra aluminaris. It is taſteleſs and mealy: one hundred parts of this ore contain above forty of ſulphur and fifty of clay, a ſmall quantity of fixed vegetable alkali, and a little iron. Bergman ſays it contains forty-three of ſulphur in one hundred, thirty-five of clay, and twenty-two of ſiliceous earth. This ore is firſt torrefied to decompoſe the ſulphur, whoſe vitriolic acid reacts on the clay, and forms the alum.

2. The

2. The pyritaceous clay, which is found at Schwemſal, in Saxony, at the depth of ten or twelve feet. It is a black and hard, but brittle ſubſtance, conſiſting of clay, pyrites, and bitumen. It is expoſed to the air for two years; by which means the pyrites are decompoſed, and the alum is formed. The alum ores of Heſſe and Liege are of this kind: but they are firſt torrefied, which is ſaid to be a diſadvantageous method.

3. The ſhiſtus aluminaris contains a variable proportion of petroleum and pyrites intimately mixed with it. When theſe laſt are in a very large quantity, this ore is rejected as containing too much iron. Profeſſor Bergman very properly ſuggeſted, that by adding a proportion of clay this ore may turn out advantageouſly for producing alum. But if the petrol is conſiderable, it muſt be torrefied. The mine of Becket in Normandy, and thoſe of Whitby in Yorkſhire, are of this ſpecies.

4. Volcanic aluminous ore. Such is that of Solfaterra near Naples. It is in the form of a white ſaline earth, after it has effloreſced in the air; or elſe it is in a ſtony form.

5. Bituminous alum ore is called ſhale, and is in the form of a ſhiſtus, impregnated with ſo much oily matter of bitumen as to be inflammable. Is found in Sweden, and alſo in the coal mines at Whitehaven, and elſewhere.

6. Alum might alſo be extracted from many ſpecies of pyrites; but ſo contaminated with iron as ſcarce to pay the expences of the operation.

The preparation of alum conſiſts in rendering the ores aluminous in the firſt place, and next in diſſolving and purifying the ſalt. Moſt of the alum ores contain clay and ſulphur, which laſt requires to be converted into vitriolic acid before it can form the aluminous combination. For this purpoſe expoſure to the air and occaſional watering is effectual, and is in many places uſed: but it is leſs expeditious than the converſion of the ſulphur into vitriolic acid by actual combuſtion. The chief difficulty of this proceſs is, that the ſulphur muſt be gradually and ſufficiently burned without expelling it by too great a heat, which would likewiſe be attended with a fuſion of the earthy parts that would render them capable of reſiſting the ſubſequent action of the water. After the ore has been, partly by calcination, and partly by ſpontaneous effloreſcence, reduced to ſuch a ſtate as that it can be made into a paſte by the hand, it is fit for boiling, which is uſually performed in large leaden caldrons. In many manufactories a cold elixation is performed, until the ſaline ſolution is ſaturated; after which it is boiled until it be ſufficiently ſtrong for cryſtallization. This ſhould not be too much loaded, becauſe otherwiſe it would begin to depoſit cryſtals by cooling before its earthy impurities had ſubſided. Some take the floating of a newly laid egg as a token of the boiling being finiſhed; a rough method indeed, as well becauſe the part above the liquor may be very different, and likewiſe becauſe the ſpecific gravity of eggs ſoon changes. The ſpecific gravity of a fluid which juſt prevents a new laid egg from ſinking is about 1.081.

The lixivium, ſufficiently concentrated by evaporation, is conveyed through channels into coolers, where, in about an hour, it is freed, by depoſition, from the groſſer heterogeneous particles; it is then put into either ſtone or wooden receptacles. In eight or ten days the lixivium, commonly called magiſtral water, flows into another veſſel, leaving behind a number of cryſtals, generally ſmall and impure, which incruſt the bottom and ſides of the veſſel. Theſe are collected, and waſhed from the impurities which adhere externally with cold water: the impurities remaining in the reſervoir after waſhing are kept by themſelves.

The waſhed cryſtals are then put into the boiler uſed for purifying them, and are diſſolved

diſſolved in a quantity of water ſo ſmall as barely to ſuſpend the ſalt when boiling hot. The alum liquor is then poured into large ſtrong wooden caſks, whoſe ſtaves and hoops are all numbered that they may be more readily put together. In theſe the alum gradually ſhoots into large cryſtals about the ſides; the liquor in the middle is then let off by a cock in the bottom, and the veſſel turned upſide down for the more effectual draining of the remaining fluid. Laſtly, the cryſtals are dried in a ſtove, and packed up in caſks for ſale.

In order to obtain the alum more pure at the ſecond cryſtallization, ſome additions are employed in many of the manufactories, ſuch as alkalis, lime, or urine. It is even aſſerted that good cryſtals of this ſalt cannot be obtained without ſuch additions. We have not any clear account what it is that theſe additions perform. Urine is thought to be uſeful only by virtue of the volatile alkali it contains. It is thought that theſe additions engage with a ſuperabundant acid, which from the decompoſition of alum by alkaline ſubſtances does not ſeem to be the only uſe. As this proceeding is attended with advantage in the treatment of many kinds of aluminous lie, it ſeems not unlikely but that it may decompoſe vitriols and other metallic ſalts which might interrupt the cryſtallization of the alum, and at the ſame time render it impure. Thus martial vitriol, a ſalt frequently abounding in the alum ores after efflorescence, would be converted into calx of iron and ſelenite by the addition of lime; both which ſubſtances would fall down, on account of their very ſparing ſolubility in that quantity of water which is ſufficient to ſuſpend the alum. So likewiſe the addition of potaſh, or the vegetable alkali, would produce calx of iron and vitriolated tartar, the latter of which requires a very conſiderable quantity of water to diſſolve it. It is ſcarcely neceſſary to purſue theſe obſervations, as they would require to be varied according to the nature of the impurities in the lie, and other circumſtances, among which the diſpoſition to form triple combinations, which exhibits itſelf where a variety of principles are ſuſpended in the ſame ſolvent, is not one of the leaſt conſiderable.

In ſuch caſes (as it is aſcertained that the alum is rendered more ſoluble, and conſequently leſs cryſtallizable, by a ſuperabundance of vitriolic acid) the moſt obvious and profitable remedy ſeems to be that of Bergman, who adviſes the addition of clay, which at the ſame time that it prevents the noxious ſuperabundance, increaſes the quantity of alum. This ſhould be added at the very firſt, when the lixivium is put into the boiler. All the lixivium may then be reduced to a tenacious maſs, and formed into cakes, which may be expoſed to the open air under a ſhed. In this ſituation the iron of the vitriol becomes more perfectly calcined by the action of the air, ſo as to retain its acid much leſs forcibly; which likewiſe, by its ſtronger attraction, is diſpoſed to unite with the clay. Calcination accelerates this effect; but it muſt be cautiouſly employed for fear of expelling the acid. In all theſe manipulations, it is evident that much may be gained or loſt in the treatment of alum ores, accordingly as the ſkill and intelligence of the manufacturer may lead him to employ ſuch proceſſes as are beſt ſuited to their contents *.

Alum is uſed in large quantities in many manufactories. It is extenſively uſeful in the art of dying. When added to tallow, it renders it harder. Printers' cuſhions, and the blocks uſed in the calico manufactory, are rubbed with burnt alum to remove any greaſineſs which might prevent the ink or colour from ſticking. Wood ſufficiently ſoaked in alum does not eaſily take fire; and the ſame is true of paper impregnated with it, which is fitter to keep gunpowder, as it alſo excludes moiſture.

* Conſult Bergman on the preparation of alum.

Paper impregnated with alum is uſeful in whitening ſilver, and ſilvering braſs without heat. Alum mixed in milk helps the ſeparation of its butter. If added in a very ſmall quantity to turbid water, in a few minutes it renders it perfectly limpid, without any bad taſte or quality; whilſt the vitriolic acid does not precipitate ſo ſoon, nor ſo well, the opake earthy mixtures that renders it turbid, and gives to it a very ſenſible acidity, as I have often tried. It is uſed in making the pyrophorus, in tanning, and many other manufactories, particularly in the art of dying, in which it is of the greateſt and moſt important uſe, by cleanſing and opening the pores on the ſurface of the ſubſtance to be dyed, rendering it fit for receiving the colouring particles (by which the alum is generally decompoſed), and at the ſame time making the colour fixed. Alum conſtitutes the baſis of crayons, which generally conſiſt of the earth of alum, finely powdered, and tinged for the purpoſe.

Alum is prepared in England, and many other parts of the world, and was formerly diſtinguiſhed by various names. The rock alum is ſuppoſed to derive its name from an ancient city in Syria, called Roccho, at preſent Edeſſa, where one of the earlieſt manufactories was carried on. The Roman alum has been conſidered as the beſt ſort. It has a roſy-coloured tinge, which ariſes from about $\frac{1}{20}$ of its weight of a roſe-coloured earth, the nature of which was not aſcertained by Bergman, though he found that the goodneſs of the alum does not depend upon it. This alum is not preferred to other good alum by our manufacturers. Plume alum is a name given to two very different ſubſtances. The one appears to be true alum produced by the deſiccation of aluminous waters, which tranſude through grottos and caverns, and leave this ſalt behind in feathery cryſtals. This is ſeldom met with. The other ſubſtance to which this name has been given, is the fibrous aſbeſtos, which contains no alum; but from half to three fourths of its weight of ſiliceous earth, from one eighth to one third of mild magneſia, and the reſt calcareous earth, with a minute proportion of clay, and ſometimes iron.

ALUTA MONTANA. This is one of the names of the coriaceous aſbeſtos, or mountain cork. It is eaſily diſtinguiſhed by its elaſticity and lightneſs, for it floats a long time on water. Its colour is either white, yellow, brown, green, or black; and its texture reſembles thoſe ſubſtances from which it has received its names: 100 parts of it contain from 56 to 62 of ſilex; from 22 to 26 of mild magneſia; from 10 to 12 of mild calcareous earth; from 2 to 2,8 of argil; and about 3 of iron.

AMALGAM. This name is applied to the combinations or mixtures of mercury with other metallic ſubſtances. As this metal is ſo exceedingly fuſible as to be always in the fluid ſtate in climates of a moderate temperature, it unites with many of the metals without any greater heat than that which it uſually poſſeſſes. For this purpoſe, therefore, nothing more is neceſſary than to triturate thin leaves, or plates, or filings of the metallic ſubſtance with mercury. In other inſtances, where the diſpoſition to combine is leſs powerful, it is found neceſſary either to fuſe or ignite the metal intended to be amalgamated. When a ſmall quantity of mercury is combined with any metal, it renders it brittle, or rather friable; a greater quantity of mercury produces a kind of imperfect fluidity reſembling that of butter. This is commonly called the conſiſtence of an amalgam. A ſtill greater quantity of mercury renders the maſs more fluid, but not uniformly ſo; for a portion of the amalgam either floats at the top, or ſinks to the bottom, inſtead of intimately combining with the whole of the mercury. This fact is of the ſame kind as that wherein ſalts are ſoluble in water in limited quantities, beyond which they ceaſe to be taken up. Mercury very readily combines with gold, ſilver, lead, tin, biſmuth, and zinc. In

making an amalgam of gold or ſilver, the clippings of the leaves from the gold-beaters may be uſed, or thin plates of the metals may be ignited, and plunged in mercury previouſly heated, ſo as to ſmoke. When the quantity of mercury is ſo large as to be fluid when cold, the ſuperfluous mercury may be ſtrained off by preſſure through a leathern bag. The remaining amalgam of gold contains about one third of its weight of mercury, but is perfectly white. The amalgam of ſilver ſinks in mercury, and conſequently is heavier than either mercury or ſilver.

Mercury unites with difficulty into an amalgam with copper and arſenic; and ſcarcely at all with platina, or with iron. This latter metal, however, does not abſolutely refuſe to combine with mercury, for it adheres to and coats the ends of iron peſtles uſed for the trituration of amalgams: and Dr. Lewis has obſerved, that a plate of tough iron is rendered brittle by keeping it immerſed in mercury for ſome days; a fact which has been experienced in another way by Mr. de Luc, who found that ſprings immerſed under mercury, in the conſtruction of a barometer, were rendered brittle and uſeleſs by its action. Iron ignited to a white heat, and thrown into a large maſs of mercury, becomes completely covered with a ferruginous bright amalgam. Regulus of antimony unites with mercury, though with great difficulty. Nickel and cobalt are ſaid not to unite with mercury; and its action on manganeſe, wolfram, and molybdena, is not known.

Amalgams are applied to a conſiderable number of uſeful purpoſes. The amalgam of gold is uſed in the proceſs called water gilding, in which the mercury firſt ſerves as the medium of adheſion between the gold and copper, and is afterwards driven off by heat. *See* GILDING. Looking glaſſes are ſilvered by an amalgam of tin. *See* SILVERING. The amalgam of zinc, triturated with tallow, is found to aſſiſt the excitation or production of electricity, by the friction of a cuſhion againſt glaſs, in a wonderful degree; inſomuch that the quantity of electricity is 20 or 30 times as great as without it.

When mercury is contaminated with any imperfect metal, it is found that by agitation, in contact with vital air, or the air of the atmoſphere, the imperfect metal becomes converted into a black powdery calx, which ſeparates from the mercury.

AMANDOLA. This is a green marble having the appearance of a honeycomb, and containing white ſpots: 100 parts of it contain 76 of mild calcareous earth; 20 of ſhiſtus; 2 of iron, partly calcined. The cellular appearance proceeds from the * ſhiſtus.

AMBER is a hard, brittle, taſteleſs ſubſtance, ſometimes perfectly tranſparent, but moſtly ſemi-tranſparent or opake, and of a gloſſy ſubſtance: it is found of all colours, but chiefly yellow or orange, and often contains leaves or inſects; its ſpecific gravity is from 1,065 to 1,000; its fracture is even, ſmooth, and gloſſy; it is capable of a fine poliſh, and becomes electric by friction; when rubbed or heated, it gives a peculiar agreeable ſmell, particularly when it melts, that is at 550 of Fahrenheit, but it then loſes its tranſparency; projected on burning coals it burns with a whitiſh flame, and a whitiſh yellow ſmoke, but gives very little ſoot, and leaves browniſh aſhes; it is inſoluble in water and ſpirit of wine, though this latter, when highly rectified, extracts a reddiſh colour from it; but it is ſoluble in the vitriolic acid, which then acquires a reddiſh purple colour, and is precipitable from it by water; no other acid diſſolves it, nor is it ſoluble in fixed alkalis, nor in eſſential

* Kirwan's Mineralogy.

nor

nor expreſſed oils, without ſome decompoſition and long digeſtion; but balſams diſſolve it readily; 75 grains of it alkalize 100 of nitre; by diſtillation it affords a ſmall quantity of water, an oil of the nature of petrol, and a peculiar acid. *See* ACID OF AMBER. Amber is met with plentifully in regular mines in ſome parts of Pruſſia. The upper ſurface is compoſed of ſand, under which is a ſtratum of loam, and under this a bed of wood partly entire, but chiefly mouldered or changed into a bituminous ſubſtance. Under the wood is a ſtratum of vitriolic or rather aluminous mineral, in which the amber is found. Strong ſulphureous exhalations are often perceived in the pits *.

Amber having been formerly conſidered as a valuable ſubſtance, and the ſpecimens, which are large, or contain entire or perfect inſects within them, being ſtill of conſiderable price, the methods of ſoftening it ſo as to introduce theſe extraneous bodies, or of uniting ſmaller pieces together, have been kept as profitable ſecrets, if it be true that they ever were diſcovered. It is ſaid that two pieces of this ſubſtance may be united by wetting them with oil of tartar, and applying them together with heat; and Wallerius mentions, that pieces of yellow amber may be ſoftened, formed into one, and even diſſolved, by means of oil of turnip-ſeed, in a gentle heat; and that, according to ſome authors, it may be rendered tranſparent by boiling in rape-ſeed oil, linſeed oil, ſalt water, &c. Neumann, however, denies that either ſalt water or linſeed oil produce this effect; though he ſtates, as the common practices of workmen, the following methods: the one conſiſts in ſurrounding the amber with ſand in an iron pot, and cementing it with a gradual fire for forty hours, ſome ſmall pieces placed near the ſides of the veſſel being occaſionally taken out for judging of the effect of the operation; the ſecond method, which he ſays is that moſt generally practiſed, is by digeſting and boiling the amber about twenty hours with rape-ſeed oil, by which it is rendered both clear and hard.

There appears to be no doubt but amber is uſed in the making of varniſhes, though probably in many inſtances the name may be uſed to recommend varniſhes not really made of this ſubſtance. The ſame general views of profit have induced artiſts to conceal their methods of making theſe varniſhes. The chief circumſtance to be attended to in this proceſs appears to conſiſt in a previous roaſting of the amber, by which its principles are altered in their arrangement, and it ſuffers a partial decompoſition, which appears to be neceſſary to render it ſoluble in linſeed oil, or eſſential oils; and it can hardly be doubted but that the quality of the varniſh will be greatly affected by the degree of torrefaction, the heat of digeſtion, and other circumſtances not eaſily determinable, except by trial and experience.

AMBERGRIS is found in the ſea, near the coaſts of various tropical countries; and is either white, black, aſh-coloured, yellow, or blackiſh; or is variegated, namely grey with black ſpecks, or grey with yellow ſpecks. A ſlight warmth ſoftens it like pitch; by a greater heat it takes fire; and its chemical products reſemble thoſe of bitumens, among which it has uſually been ranked. Its ſmell is peculiar, and not eaſy to be counterfeited: linſeed oil diſſolves it by the aſſiſtance of heat; as does likewiſe ſtrong ardent ſpirit at the heat of ebullition. The quantity taken up by ardent ſpirit is about $\frac{1}{12}$ part of its weight; and if the ſpirit be ſuffered to exhale by ſpontaneous evaporation, part of the diſſolved matter ſeparates in the form of a white

* Neumann's Chemiſtry.

unctuous ſubſtance reſembling tallow, which however is taken up again upon the addition of more ſpirit.

It is at preſent a general opinion that ambergris is an excrementitious ſubſtance voided by the phyſeter-macrocephalus, or ſpermaceti whale. This is chiefly grounded on the enquiries and obſervations of Dr. Swediar, in the Philoſophical Tranſactions for the year 1783. Mr. Magellan, however, mentions an undoubtedly vegetable ambergris gathered from a tree which grows in Guyana, and is called Cuma. Specimens of this were preſented to him by Mr. Aublet, author of the Hiſtoire de la Guyane, publiſhed in 1774, who himſelf collected it on the ſpot; and Mr. Magellan preſented part of it to the late Dr. Fothergill, and alſo to Dr. Combe. It is of a whitiſh brown colour with a yellowiſh ſhade; melts and burns like wax on the fire, but is rather of a more powdery conſiſtence, ſays this author *, than any amber (or rather ambergris) he had ſeen.

AMETHYST. The amethyſt is a gem of a violet colour and great brilliancy, ſaid to be as hard as the ruby or ſapphire, from which it only differs in colour. This is called the oriental amethyſt, and is very rare. When it inclines to the purple or roſy colour, it is more eſteemed than when it is nearer to the blue. Theſe amethyſts have the ſame figure, hardneſs, ſpecific gravity, and other qualities, as the beſt ſapphires or rubies, and come from the ſame places, particularly from Perſia, Arabia, Armenia, and the Weſt Indies. The occidental amethyſts are merely coloured cryſtals or quartz.

AMMONIAC GUM. This is a gum reſin, from an ounce of which ſix drams may be diſſolved in ardent ſpirit, or ſix drams two ſcruples and a half by water, according to Newman.

AMMONIACAL SALTS. The combination of marine acid and volatile alkali is known by the name of ſal ammoniac, a name which has been variouſly derived. By ſome it is taken from one of the Cyrenaic territories, Ammonia; by others from the temple of Jupiter Ammon; and by others from the Greek word which denotes ſand, the ſalt being ſaid to have been found plentifully in Ammonia, and near Ammon's temple, in ſandy grounds. Salts containing the volatile alkali are very commonly called ammoniacal ſalts.

It is however a ſubject of controverſy whether the ſal ammoniac of the ancients was not of a different nature from that which we diſtinguiſh by the ſame name; and whether it was not marine ſalt or mineral alkali, as the true modern ſal ammoniac is never found native, or at leaſt not in any tolerably pure ſtate. Common ſal ammoniac is an artificial preparation formerly made only in Egypt; and its component parts were long known to the European chemiſts before any attempts were made to manufacture it here. By various accounts it is ſtated that the Egyptians procure it by ſublimation from ſoot of cows' dung or camels' dung, urine, and common ſalt: but from ſubſequent accounts, tranſmitted to the Royal Academy at Paris, it appears to be incontrovertibly eſtabliſhed, that this ſalt is procured by ſublimation from the ſoot alone without any addition. The chimneys in which cow-dung only is burnt are ſaid to furniſh the beſt ſoot, and this yields between one fourth and one fifth of its weight of ſal ammoniac; but in the general courſe of theſe operations the product is not more than one ſeventh of the whole weight of ſoot. The ſubliming veſſels are of various ſizes, the ſmalleſt containing about twelve pounds of ſoot, and the largeſt fifty; but they fill them only about three quarters full, in order to leave room for the ſublimation of the ſalt.

* Magellan's Cronſtedt, page 458.

The

The furnace in which theſe balloons are placed conſiſts of four walls built in a quadrangular form. The two front walls are ten, and the ſides nine feet long: but they are all five feet high and ten inches thick. Within the quadrangle formed by theſe walls, three arches run lengthwiſe from end to end thereof, at the diſtance of ten inches aſunder. The mouth of this furnace is in the middle of one of its fronts, and of an oval form; two feet four inches high, and ſixteen inches wide.

The balloons lie in the ſpaces between the arches of the furnace, which ſerve inſtead of a grate to ſupport them. Four of them are uſually placed in each interval, which makes ſixteen for one furnace. They are ſet at the diſtance of about half a foot from each other, and ſecured in their places with brick and earth: but they leave about four inches on the upper part of the balloon uncovered, with a view to promote the ſublimation, as they alſo do ſix inches of the inferior part, that the heat may the better act on the matter to be ſublimed. Things being thus prepared, they firſt make a fire with ſtraw, which they continue for an hour. Afterwards they throw in cows' dung made up in ſquare cakes like bricks. (The want of wood in this country is the reaſon that they generally make uſe of this fuel.) Theſe cakes of dung add to the violence of the fire, which they continue in this manner for nineteen hours; after which they increaſe it conſiderably for fifteen hours more, and then they ſlacken it by little and little.

When the matter contained in the veſſels begins to grow hot, that is, after ſix or ſeven hours baking, it emits a very thick and ill-ſcented ſmoke, which continues for fifteen hours. For hours after that the ſal ammoniac is obſerved to riſe in white flowers, which adhere to the inſide of the neck of the veſſel; and thoſe who have the direction of the operation take care, from time to time, to paſs an iron rod into the neck of the balloon, in order to preſerve a paſſage through the ſaline vault for giving vent to ſome blueiſh vapours, which conſtantly iſſue out of the veſſel during the whole operation *.

The preparation of ſal ammoniac, in the European manufactories, has been already mentioned under the article of ALKALI, VOLATILE, which ſee.

The taſte of ſal ammoniac is penetrating, acrid, and urinous. The form of its cryſtals is that of a ſix-ſided, very long pyramid, the union of which cauſes the ſublimed ſalt to poſſeſs a ſtriated texture. This ſalt is remarkably deficient in that degree of brittleneſs which characterizes ſaline cryſtals. It appears to be in ſome meaſure flexible, and has ſo much elaſticity, that it rebounds under the ſtroke of a hammer, and cannot without difficulty be pulverized, or broken into ſmall pieces. This ſalt is totally volatile, though it requires a conſiderable heat to raiſe it, nearly the ſame as melts lead. This is the beſt method of purifying ſal ammoniac. It ſeems, however, by reports of ſome of the earlier chemiſts, that repeated ſublimations alter the properties of this ſalt, and render it leſs conſiſtent. This fact requires to be more particularly examined, before any explanation can with propriety be offered. It is not improbable, however, that part of the volatile alkali may be decompoſed in theſe repeated ſublimations; the conſequence of which would be, that the remaining ſalt would poſſeſs a redundancy of acid.

Sal ammoniac ſuffers no change by long expoſure to the air. It is very ſoluble in water, ſix parts of that fluid being ſufficient, at a common temperature, to diſſolve one of the ſalt. This ſolution produces a very conſiderable depreſſion of temperature: an effect which always takes place on the ſpeedy ſolution of ſaline cryſtals, and appears to depend on the tranſition of their water of cryſtallization from a ſolid

* Lemaire and Granger, quoted by Macquer in his Elements of Chemiſtry, II. 391.

to a fluid ſtate. *See* HEAT. Boiling water diſſolves nearly its own weight of ſal ammoniac, and depoſits cryſtals by cooling; though the moſt regular cryſtals of this, as well as other ſalts, are obtained by ſpontaneous evaporation.

Sal ammoniac is not decompoſed by clay, and difficultly by magneſia; lime, ponderous earth, and the fixed alkalis, decompoſe it, as well in the humid as in the dry way, by combining with its acid. The vitriolic and nitrous acids ſeize its alkali. It detonates with nitre, no doubt by the decompoſitions of the volatile alkali and nitrous acid. Hence it ſhould appear, that the reſidue will conſiſt of common ſalt, and the volatile product will be chiefly phlogiſticated air. But theſe facts require to be more particularly examined.

Sal ammoniac is made uſe of in medicine, and is extenſively uſeful in various buſineſſes; ſuch as dyers, glaſs makers, and more particularly thoſe who work in metals, for ſoldering, or cauſing one metal to adhere to the ſurface of another. *See* SOLDERING; TINNING.

AMMONITES. This petrifaction, which has likewiſe been diſtinguiſhed by the name of cornu ammonis, and is called the ſnake ſtone by the vulgar, conſiſts chiefly of lime-ſtone, or mild calcareous earth. They are found of all ſizes, from the breadth of half an inch to more than two feet in diameter; ſome of them rounded, others greatly compreſſed, and lodged in different ſtrata of ſtones and clays. They appear to owe their origin to ſhells of the nautilus kind.

AMOMUM. *See* PIMENTO.

AMPELYTES. A ſolid, dry, hard, opake, black, foſſil coal, not fuſible, but eaſily inflammable, and burning with a bright vivid white flame, with much ſmoke, and a bituminous or pitchy ſmell. In the north of England it is called canal coal, perhaps by corruption, inſtead of candle coal, as it is uſed to ſupply the place of candles in poor families. An alum ore found in Burgundy, and conſiſting of clay, pyrites, and bitumen, is alſo diſtinguiſhed by this name.

AMYGDALOIDES, *or* MANDEL-STEIN. A ſtone of the ſiliceous genus, which conſiſts of a martial jaſper, in which elliptical kernels of calcareous ſpar and ſerpentine ſtone are included.

ANALYSIS. The chemical analyſis conſiſts of a great variety of operations performed for the purpoſe of ſeparating component parts of bodies. In theſe operations, the moſt extenſive knowledge of ſuch properties of bodies as are already diſcovered muſt be applied, in order to produce ſimplicity of effect and certainty in the reſults. The chemical analyſis can hardly be made with ſucceſs by one who is not in poſſeſſion of a conſiderable number of ſimple ſubſtances in a ſtate of great purity, many of which, from their effects, are called re-agents. The word analyſis is applied by chemiſts to denote that ſeries of operations by which the component parts of bodies are determined, whether they be merely ſeparated, or exhibited apart from each other; or whether theſe diſtinctive properties are exhibited, by cauſing them to enter into new combinations, without the perceptible intervention of a ſeparate ſtate. The forming of new combinations is called ſyntheſis; and, in the chemical examination of bodies, analyſis or ſeparation can ſcarcely ever be effected without ſyntheſis taking place at the ſame time.

As moſt of the improvements in the ſcience of chemiſtry conſiſt in bringing the art of analyſis nearer to perfection, it is not eaſy to give any other rule to the learner, than the general one of conſulting and remarking the proceſſes of the beſt chemiſts, ſuch as Scheele, Bergman, Berthollet, Kirwan, and others. The bodies which preſent themſelves more frequently for examination than others, are minerals and mineral waters. In the examination of the former, it was the habit of the earlier che-

miſts to avail themſelves of the action of fire, with very few humid proceſſes, which are ſuch as might be performed in the uſual temperature of the atmoſphere. Modern chemiſts have improved the proceſs by fire, by a very extenſive uſe of the blow-pipe (*ſee* BLOW-PIPE); and have ſucceeded in determining the component parts of minerals to great accuracy in the humid way. For the method of analyſing mineral waters, *ſee* WATERS, MINERAL; and for the analyſis of metallic ores, ſee the reſpective metals.

Several authors have written on the examination of earths and ſtones: the following is the method of Mr. Kirwan.

When earths, or pulverulent mineral ſubſtances, are well dried, and ſeparated from every viſible heterogeneous ſubſtance, a portion of them ſhould be weighed, and diſtilled in a glaſs retort until the bottom begins to grow red hot. In ſome caſes it may be proper to receive the air that ariſes in a pneumatic apparatus; and in all it will be proper to examine what diſtils over or ſublimes, whether it be acid or alkaline, with paper tinged blue by litmus, and part of its ſurface reddened by diſtilled vinegar. If the blue be reddened, an acid exiſts in the diſtilled liquid; if the red be effaced, and the blue reſtored, a volatile alkali is the cauſe of it; if the liquor precipitates lime-water, but does not precipitate a ſolution of nitrous ſelenite, or the ſalt formed by lime and nitrous acid, then it contains fixed air; if it precipitates alſo nitrous ſelenite, it contains the vitriolic acid; if it contains the marine acid, it will not precipitate nitrous ſelenite, but it will the nitrous ſolution of ſilver. The loſs of weight of the reſiduum in the retort, and the weight of water in the receiver, will ſhew the proportion of the volatile ingredients.

Another portion of the earth to be examined ſhould be digeſted in about ſix or eight times its weight of pure water, and the properties of that water examined to find whether the earth contains neutral ſalts. *See* WATERS, MINERAL.

The firſt ſteps in the examination of conſiſtent earths or ſtones is ſomewhat different from that of ſuch as are pulverulent. Their ſpecific gravity ſhould firſt be examined; alſo their hardneſs, whether they will ſtrike fire with ſteel, or can be ſcratched by the nail, or only by cryſtal, or ſtones of ſtill greater hardneſs; alſo their texture, perviouſneſs to light, and whether they be manifeſtly homogeneous or compound ſpecies, &c.

2d. In ſome caſes, one ſhould try whether they imbibe water, or whether water can extract any thing from them by ebullition or digeſtion.

3d. Whether they are ſoluble in, or effervеſce with, acids, before or after pulverization; or whether decompoſable by boiling in oil of tartar, &c. as gypſums and ponderous ſpars are.

4th. Whether they detonate with nitre.

5th. Whether they yield the ſparry acid by diſtillation with oil of vitriol, or a volatile alkali by diſtilling them with ſalt of tartar.

6th. Whether they are fuſible per ſe with a blow-pipe, and how they are affected by mineral alkali, borax, and microcoſmic ſalt; and whether they decrepitate when gradually heated.

7th. Stones that melt per ſe with the blow-pipe are certainly compound, and contain at leaſt three ſpecies of earth, of which the calcareous is probably one; and if they give fire with ſteel, the ſiliceous is probably another.

The beſt general ſolvent for ſtones or earths appears to be aqua regia, compoſed of two parts nitrous and one of marine acid: if the ſtone or earth effervеſces ſtrongly with acids, no other preparation is requiſite than a ſeparation of ſuch parts as are viſibly heterogeneous, and pulverization; the ſolution is then eaſily performed in a digeſting

digeſting heat, if requiſite. The undiſſolved reſiduum, if purely ſiliceous, will melt into a tranſparent glaſs with about $\frac{1}{2}$ its weight of mineral alkali; if not, it is ſtill compounded, and its ſoluble parts will yield to a reiterated digeſtion.

If the ſtone does not effervеſce, or eaſily diſſolve in acids after pulverization and digeſtion, but leaves an inſoluble reſiduum evidently compound, or but ſlightly altered, it will require to be pulverized, and mixed with twice or thrice its weight of mineral alkali, and to be expoſed to a low red heat for one or two hours. Mica was found to require a mixture of 4 times its weight of mineral alkali; after which it is to be ſeparated from the alkali by lixiviation and filtration, waſhing it with diſtilled water until the water is abſolutely taſteleſs, and precipitates no metallic ſolution.

The powdered ſtone, thus edulcorated, is to be dried by heating it to redneſs, and then weighed, and 100 grains taken for ſubſequent experiments: it were better if ſtill more were uſed, but the analyſis would be more expenſive.

The powder is next to be digeſted in 8 or 10 times its weight of aqua regia, in a boiling heat, in a retort to which a receiver is luted, and the digeſtion reiterated as long as any thing appears to be diſſolved by freſh portions of the acid. Mica was found to require 50 times its weight of aqua regia before it was entirely decompoſed, as the acid is ſo volatile as very ſoon to diſtil over. Oil of vitriol has the advantage of bearing a greater heat, diſſolving ponderous ſpar, and of acting more powerfully on clay than aqua regia; but a large retort muſt be uſed, for often towards the end it puffs and throws up the earth or ſtone, and carries it into the receiver; beſides, it does not ſufficiently act on calces of iron, if theſe be much dephlogiſticated. Spirit of nitre affects them ſtill leſs: hence Mr. Kirwan often uſes oil of vitriol firſt, then what has been diſſolved he precipitates by a mild alkali, and re-diſſolves the precipitate in aqua regia. A perfect ſolution being thus effected, the reſiduum is to be well waſhed, and the waſhings added to the ſolution: the reſiduum, well dried and weighed, gives the weight of ſiliceous earth in the compound.

The ſolution is next to be examined; which we will ſuppoſe to contain the four ſoluble earths, calcareous, ponderous, magneſian, and argillaceous, and alſo a calx of iron. It always contains an exceſs of acid, of which it is in great meaſure deprived by boiling for a conſiderable time, as both acids are very volatile, and indeed of the marine none remains but what is combined with the calx of iron, as the nitrous chaſes it from the earths. By getting rid of this exceſs of acid, leſs alkali will be required for the ſucceeding precipitation, and leſs aerial acid ſet looſe which would retain much of the precipitate by re-diſſolving it: the ſolution ſhould then be evaporated to about half a pint.

The ſolution being thus prepared, it is uſual to precipitate the calx of iron from it by the Pruſſian alkali; but to this method Mr. Kirwan has two objections: 1ſt. that the ponderous earth, if any, would alſo be precipitated and confounded in the Pruſſian blue; and 2d. that this precipitation, beſides being exceeding ſlow, ſeldom fails of leaving ſome iron ſtill in the ſolution, as the exceſs of the Pruſſian alkali, which muſt neceſſarily be added to be certain that all the iron is precipitated, never fails to re-diſſolve a portion of the Pruſſian blue which thus remains in the liquor and cannot be got rid of. Hence the method he uſes is as follows: Firſt, he prepares the Pruſſian alkali after the manner of Mr. Bergman, by digeſting and boiling a pure alkaline ſolution over Pruſſian blue, until the alkali no longer effervеſces with acids, nor precipitates a ſolution of nitrous ſelenite, or any other earth, except the barytes: he even makes it a little ſtronger; for if it be barely ſaturated with the tinging matter, it ſoon ſpoils and precipitates other earths; the tinging matter evaporating,

porating, he next examines how much of this alkali is neceſſary to precipitate one grain of iron from its ſolution in dilute vitriolic or marine acid, and marks this on the label of the bottle that contains the alkali. Next follows the application.

The ſolution of the earths being weighed, take 100 grains of it, and on theſe gradually pour the Pruſſian alkali (a portion of which is alſo previouſly weighed), until all the iron, or ponderous earth and iron, is precipitated; the weight of the alkali uſed gives that of the iron contained in 100 grains of the ſolution, and the quantity contained in 100 grains of the ſolution gives that contained in the whole ſolution, by the rule of proportion, from which the ponderous earth, if any be found in ſubſequent experiments, is to be deducted.

The quantity of iron being thus found, the remainder of the ſolution is to be precipitated by aerated or mild mineral alkali, and then boiled for half an hour, to expel as much as poſſible of the fixed air; by this means the whole of its contents are precipitated, and nothing remains in ſolution but cubic nitre and a little common ſalt: when the precipitate has ſettled, after one or two days reſt, the liquor is to be poured off, and the laſt portions taken up with a glaſs ſyringe. Diſtilled water is then to be added to the precipitate, and boiled over it, and afterwards poured off, and taken up until it comes off taſteleſs.

The precipitate being ſufficiently dried, is to be re-diſſolved in nitrous acid twice, and evaporated to dryneſs; then calcined for one hour in a white heat; and, laſtly, treated with about ſix or eight times its weight of diſtilled vinegar, in a heat of about 60 degrees, for one or two hours: by this means the ponderous, calcareous, and magneſian earths will be extracted and ſeparated from the clay and calx of iron, which will remain undiſſolved.

Of this acetous ſolution 100 grains ſhould be taken and examined with the Pruſſian alkali: if any part be precipitated it is ponderous earth, and by heating this to redneſs its weight may be known; or ſtill better, by a previous experiment determining the quantity requiſite to precipitate one grain of acetous baroſelenite, and, by the rule of proportion, the quantity of it in the whole ſolution may be found.

The remainder of the acetous ſolution is to be evaporated to dryneſs, and heated white in a clean poliſhed iron crucible for two hours, then weighed and thrown into hot diſtilled water: the calcareous earth (if any) will be diſſolved in a ſufficient quantity of this water, of which an ounce can ſcarcely diſſolve one grain, ſo that frequent affuſions of hot water may be requiſite; the magneſia will remain undiſſolved, and is to be dried and weighed; its weight gives that of the pure calcareous earth, from which that of the ponderous (if any) is to be deducted: the lime-water may alſo be precipitated by an aerated alkali.

Laſtly, the clay, and calx of iron, which remained undiſſolved by the acetous acid, are to be heated ſlightly, to prevent their cohering, and reiteratedly boiled in dephlogiſticated nitrous acid to dryneſs, and finally diſſolved in that acid, which will then take up only the clay, which may be precipitated, dried, and weighed; though indeed this troubleſome operation may be unneceſſary, as the weight of the martial part being known by the experiment with the Pruſſian alkali, that of the clay is known of courſe when only the two remain. This is even better, as the calx always increaſes in weight by theſe operations.

Beſides this general method, ſome others may be uſed in particular caſes.

Thus, to diſcover a ſmall proportion of argillaceous earth or magneſia in a ſolution of a large quantity of calcareous earth, cauſtic volatile alkali may be applied, which will precipitate the clay or magneſia (if any be), but not the calcareous earth. Diſtilled vinegar applied to the precipitate will diſcover whether it be clay or magneſia.

2dly. A minute portion of calcareous or ponderous earth, in a ſolution of argillaceous earth or magneſia, may be diſcovered by the vitriolic acid which precipitates the calcareous and ponderous: the ſolution ſhould be dilute, elſe the clay alſo would be precipitated. If there be not an exceſs of acid, the ſaccharine acid is ſtill a nicer teſt of calcareous earth: 100 grains of gypſum contain about 32 of calcareous earth; 100 grains of baroſelenite contain 84 of ponderous earth; 100 grains of ſaccharine ſelenite contain 45 of calcareous earth. The inſolubility of baroſelenite in 500 times its weight of boiling water ſufficiently diſtinguiſhes it. From theſe data the quantities are eaſily inveſtigated.

3dly. A minute proportion of argillaceous earth in a large quantity of magneſia may be diſcovered either by precipitating the whole, and treating it with diſtilled vinegar, or by heating the ſolution nearly to ebullition, and adding more aerated magneſia until the ſolution is perfectly neutral, which it never is when clay is contained in it, as this requires an exceſs of acid to keep it in ſolution. By this means the clay is precipitated in the ſtate of embryon alum, which contains about half its weight of clay (or for greater exactneſs it may be decompoſed by boiling it in volatile alkali). After the precipitation the ſolution ſhould be largely diluted, as the Epſom ſalt, which remained in ſolution while hot, would precipitate when cold, and mix with the embryon alum.

4thly. A minute portion of magneſia in a large quantity of argillaceous earth is beſt ſeparated by precipitating the whole, and treating the precipitate with diſtilled vinegar.

Laſtly, Calcareous earth and barytes, or ponderous earth, are ſeparated either by precipitating the barytes by the Pruſſian alkali, or the calcareous by a cauſtic fixed alkali, or by precipitating both with the vitriolic acid, and evaporating the ſolution to a ſmall compaſs, pouring off the liquor, and treating the dried precipitate with 500 times its weight of boiling water; what remains undiſſolved is baroſelenite, or ponderous ſpar.

ANGELICA. The roots have a pungent agreeable bitteriſh taſte, and a ſtrong aromatic ſmell, ſomewhat of the muſky kind. Their activity reſides in an eſſential oil and a reſinous matter. The oil is obtained by diſtillation with water. The oil and the reſin are totally extracted by digeſtion in ardent ſpirit; and water by the like treatment extracts them, though in part only.

Theſe roots, like thoſe of moſt of the umbelliferous plants, are very apt to be preyed upon by worms, to become carious, and fall into powder. So long as they are merely worm-eaten, and not powdery, they are as fit for making the eſſential oil, or the tinctures in ardent ſpirit or water, as in their moſt perfect ſtate; the inſects preying firſt upon the mucilaginous and inſipid parts, and not upon the reſinous and oily parts. When ſuch roots are made uſe of, care muſt be taken to beat out the worms and duſt as much as poſſible. To preſerve the roots of Angelica, they muſt be thoroughly dried, and kept in cloſe veſſels or packages in a dry place.

ANIL, *or* NIL. This plant, from the leaves of which indigo is prepared, grows in America. It has ſeveral ſlender knotty ſtalks which ſpread into ſmall branches, clothed each with from four to ten pair of leaves, and an odd one at the end. The leaf is ſmall, fleſhy, and ſoft, of a greeniſh brown colour on the upper ſide, pale and as it were ſilvery-coloured beneath. The plant riſes to the height of about two feet, and produces reddiſh flowers, in ſhape reſembling thoſe of broom, but ſmaller, followed by oblong pods containing the ſeeds.

The culture of this plant is as follows *: The ground being thoroughly cleared

* Labat, quoted by Lewis on Neumann, II. 237.

of

of weeds, which is a principal object, a number of ſlaves, ranged in a line, march acroſs, making little trenches of the width of their hoes, and two or three inches deep, about a foot diſtant from each other every way. Then returning, they drop ſome ſeeds in each trench, and afterwards cover them with the earth taken out. In moiſt weather the plant comes up in two or three days; and in about two months it is fit for cutting. If ſuffered to ſtand till it runs into flower, the leaves become too dry and too hard, and the indigo obtained from them proves leſs in quantity and leſs beautiful. The due point of maturity is known by the leaves beginning to grow leſs ſupple or more brittle. In a rainy ſeaſon the cutting may be repeated every ſix weeks. Cutting in dry weather kills the plant, which, if that is avoided, continues to afford freſh crops for two years. For the preparation of INDIGO, ſee that article.

ANIMAL KINGDOM. The various bodies around us, which form the objects of chemical reſearch, have all undergone a number of combinations and decompoſitions before we take them in hand for examination. Theſe are all conſequences of the ſame attractions or ſpecific properties that we avail ourſelves of, and are modified likewiſe by virtue of the ſituations and temperatures of the bodies preſented to each other. In the great maſs of unorganized matter, the combinations appear to be much more ſimple than ſuch as take place in the veſſels of organized beings, namely plants and animals: in the former of which there is at leaſt a peculiar ſtructure of tubes conveying various fluids; and in the latter there is not only a moſt elaborate ſyſtem of veſſels, but likewiſe for the moſt part an augmentation of temperature. From ſuch cauſes as theſe it is that ſome of the ſubſtances afforded by animal bodies are never found either in vegetables or minerals; and ſo likewiſe in vegetables are found certain products never unequivocally met with among minerals. Hence, among the ſyſtematical arrangements uſed by chemiſts, the moſt general is that which divides bodies into three kingdoms, the animal, the vegetable, and the mineral.

Animal as well as vegetable bodies may be conſidered as peculiar apparatus for carrying on a determinate ſeries of chemical operations. Vegetables ſeem capable of operating with fluids only, and at the temperature of the atmoſphere, as we have juſt noticed. But moſt animals have a proviſion for mechanically dividing ſolids by maſtication, which anſwers the ſame purpoſe as grinding, pounding, or levigation does in our experiments; that is to ſay, it enlarges the quantity of ſurface to be acted upon by ſolvents. The proceſs carried on in the ſtomach appears to be of the ſame kind as that which we diſtinguiſh by the name of digeſtion; and the bowels, whatever other uſes they may ſerve, evidently form an apparatus for filtering or conveying off the fluids; while the more ſolid parts of the aliments, which are probably of ſuch a nature as not to be rendered fluid, but by an alteration which would perhaps deſtroy the texture of the machine itſelf, are rejected as uſeleſs. When this filtered fluid paſſes into the circulatory veſſels, through which it is driven with conſiderable velocity by the mechanical action of the heart, it is ſubjected not only to all thoſe changes which the chemical action of its parts is capable of producing, but is likewiſe expoſed to the air of the atmoſphere in the lungs, into which that elaſtic fluid is admitted by the act of reſpiration. Here it undergoes a change of the ſame nature as happens to other combuſtible bodies when they combine with its vital part. This vital part becomes condenſed, and combines with ſome principle emitted from the blood; at the ſame time that it gives out a large quantity of heat, in conſequence of its own capacity for heat being diminiſhed. It has not been aſcertained whether the ſubſtance which converts the inſpired vital air into fixed air (of which a portion is ex-

pired from the lungs together with the noxious or phlogiſticated air) be inflammable air or charcoal; and it has likewiſe been doubted whether any part of the vital air is abſorbed by the blood. Later experiments of Dr. Prieſtley ſhew however that this laſt event does actually take place *.

It would lead us too far from our purpoſe, if we were to attempt an explanation of the little we know reſpecting the manner in which the ſecretions or combinations that produce the various animal and vegetable ſubſtances are effected, or the uſes of thoſe ſubſtances in the economy of plants and animals. Moſt of them are very different from any of the products of the mineral kingdom. We ſhall therefore only add, that theſe organized beings are ſo contrived, that their exiſtence continues, and all their functions are performed, as long as the veſſels are ſupplied with food or materials to occupy the place of ſuch as are carried off by evaporation from the ſurface, or otherwiſe, and as long as no great change is made, either by violence or diſeaſe, in thoſe veſſels or the fluids they contain. But as ſoon as the entire proceſs is interrupted in any very conſiderable degree, the chemical arrangements become altered; the temperature in land animals is changed, the minute veſſels are acted upon and deſtroyed, life ceaſes, and the admirable ſtructure, being no longer ſufficiently perfect, loſes its figure, and returns, by new combinations and decompoſitions, to the general maſs of unorganized matter, with a rapidity which is uſually greater, the more elaborate its conſtruction.

The parts of vegetable or animal ſubſtances may be obtained, for chemical examination, either by ſimple preſſure, which empties the veſſels of their contents; by digeſtion in water, or in other fluids, which diſſolve certain parts, and often change their nature; by deſtructive diſtillation, in which the application of a ſtrong heat alters the combination of the parts, and cauſes the new products to paſs over into the receiver in the order of their volatility; by ſpontaneous decompoſition or fermentation, wherein the component parts take a new arrangement, and form compounds which did not for the moſt part exiſt in the organized ſubſtance; or, laſtly, the judicious chemiſt will avail himſelf of all theſe ſeveral methods ſingly, or in combination. He will, according to circumſtances, ſeparate the parts of an animal or vegetable ſubſtance by preſſure, aſſiſted by heat; or by digeſtion or boiling in various fluids added in the retort which contains the ſubſtance under examination. He will attend particularly to the products which paſs over, whether they be permanently elaſtic, or ſubject to condenſation in the temperatures we are able to produce. In ſome caſes he will ſuffer the ſpontaneous decompoſition to precede the application of chemical methods; and in others he will attentively mark the changes which the products of his operations undergo in the courſe of time, whether in cloſed veſſels, or expoſed to the open air. Thus it is that, in ſurveying the ample field of nature, the philoſophical chemiſt poſſeſſes numerous means of making diſcoveries, if applied with judgment and ſagacity; though the progreſs of diſcovery, ſo far from bringing us nearer the end of our purſuit, appears continually to open new ſcenes, and, by enlarging our powers of inveſtigation, never fails to point out additional objects of enquiry.

Animal and vegetable ſubſtances approach each other by inſenſible gradations; ſo that there is no ſimple product of the one which may not be found in greater or leſs quantity in the other. The moſt general diſtinctive character of animal ſubſtances is that of affording volatile alkali by deſtructive diſtillation. Some plants however afford it likewiſe. Neither contain it ready formed; but it appears to be

* Phil. Tranſ. lxxx. 106.

produced

produced by the combination of phlogiſticated and inflammable air, during the changes produced either by fire, or by the putrefactive proceſs. *See* ALKALI, VOLATILE; and AIR, PHLOGISTICATED.

Few of the products of the animal kingdom have been ſubjected to chemical analyſis. For this reaſon it is not practicable to arrange them according to the nature of their component parts. Animal ſubſtances may therefore be conveniently divided into, 1. Such as are uſually obtained without deſtroying life. Theſe are milk, eggs, urine, excrement, the matter of perſpiration, ambergris, &c. wax, honey, gum-lack, ſilk, hair, horn, feathers, &c. Or, 2. Such parts of animals as are obtained by deſtroying them, or depriving them of life. Theſe are blood; various ſolids confounded under the name of fleſh, fat, ſpermaceti, bile, the gaſtric juice, and ſeveral acids; together with calcareous earth, and other ſubſtances common to the mineral and vegetable kingdoms. For the properties of which, ſee the reſpective articles.

When animal ſubſtances are left expoſed to the air, or immerſed in water or other fluids, they ſuffer a ſpontaneous change, which is more or leſs rapid according to circumſtances. The ſpontaneous change of organized bodies is diſtinguiſhed by the name of fermentation. In vegetable bodies there are diſtinct ſtages or periods of this proceſs, which have been divided into the vinous, acetous, and putrefactive fermentations. Animal ſubſtances are ſuſceptible only of the latter, during which, as in all other ſpontaneous changes, the combinations of chemical principles become in general more and more ſimple. There is no doubt but much inſtruction might be obtained from accurate obſervations of the putrefactive proceſſes in all their ſeveral varieties and ſituations; but the loathſomeneſs and danger attending on ſuch enquiries has hitherto greatly retarded our progreſs in this department of chemical ſcience. *See* FERMENTATION.

ANIME, improperly called gum anime, is a reſinous ſubſtance imported from New Spain and the Braſils. There are two kinds, diſtinguiſhed by the names of oriental and occidental. The former is dry, and of an uncertain colour, ſome ſpecimens being greeniſh, ſome reddiſh, and ſome of the brown colour of myrrh. The latter is in yellowiſh, white, tranſparent, ſomewhat unctuous tears, and partly in larger maſſes, brittle, of a light pleaſant taſte, eaſily melting in the fire, and burning with an agreeable ſmell. Like reſins it is totally ſoluble in ardent ſpirit, and alſo in oil. Water takes up about $\frac{1}{16}$ of the weight of this reſin by decoction. The ſpirit drawn off by diſtillation has a conſiderable degree of the taſte and flavour of the anime; the diſtilled water diſcovers on its ſurface ſome ſmall portion of eſſential oil.

This reſin is uſed by perfumers, and alſo in certain plaſters, wherein it has been ſuppoſed to be of ſervice in nervous affections of the head and other parts; but there are no reaſons to think that, for medical purpoſes, it differs from common reſins.

ANISEED contains, beſides its eſſential odorous oils, a groſs one of the expreſſible kind. The eſſential oil, and the ſmell and taſte of the ſeeds which depend upon it, are confined to the outer thin ſkin: the inner kernel, which is commonly divided longitudinally into two portions, has little or no ſmell, and exceeding little taſte: in this reſides the groſs oil, naturally inodorous and inſipid, but which, nevertheleſs, in its ſeparation from the ſeed by the preſs, brings with it a part of the eſſential oil, ſo as to become ſtrongly impregnated with the peculiar flavour of the aniſeed; its colour is greeniſh.

The eſſential oil, though mild in taſte, has an extremely ſtrong ſmell, which it

communicates to whatever it touches in ſuch a degree as ſcarcely to be overpowered. It coagulates in a temperature much warmer than is neceſſary to freeze water. The term of its congelation, which ſeems to be about 50 degrees of Fahrenheit's thermometer, but is not very eaſy to be determined with great accuracy, becauſe it is a bad conductor of heat, was propoſed by Boyle, in the infancy of the thermometer, to be uſed as a fixed point in the graduation of that inſtrument. This oil, like other eſſential oils, is ſoluble in ardent ſpirit, from which it in part ſeparates by cooling. Neumann obſerves that it diſſolves ſulphur in greater quantity than any other oil expreſſed or diſtilled. Another ſingular fact is noticed by the ſame author, viz. that whereas the diſtillation of eſſential oil from other vegetables is in general facilitated by the addition of ſalt to the water which is added to the vegetable ſubſtance, ſuch an addition is particularly hurtful in this proceſs, the aniſeed yielding only half as much oil as it does when diſtilled with pure water.

ANNEAL. We know too little of the arrangement of particles to determine what it is that conſtitutes or produces brittleneſs in any ſubſtance. In a conſiderable number of inſtances of bodies which are capable of undergoing ignition, it is found that ſudden cooling renders them hard and brittle. This is a real inconvenience in glaſs, and alſo in ſteel, when this metallic ſubſtance is required to be ſoft and flexible. The inconveniences are avoided by cooling them very gradually, and this proceſs is called annealing. Glaſs veſſels, or other articles, are carried into an oven or apartment over the great furnace, where they are permitted to cool in a greater or leſs time according to their thickneſs and bulk. The annealing of ſteel, or other metallic bodies, conſiſts ſimply in heating them, and ſuffering them to cool again either upon the hearth of the furnace, or in any other ſituation where the heat is moderate, or at leaſt the temperature is not very cold.

ANNOTTO. The pellicles of the ſeeds of a certain American tree afford the red maſſes brought into Europe under the name of Annotto, Orlean, and Roucou. The red ſeeds, cleared from the pods, are ſteeped in water for ſeven or eight days, or longer, till the liquors begin to ferment; then ſtrongly ſtirred, and ſtamped with wooden paddles and beaters, to promote the ſeparation of the red ſkins: this proceſs is repeated ſeveral times till the ſeeds are left white. The liquor paſſed through cloſe cane ſieves is pretty thick, of a deep red colour, and very ill ſmell: in boiling it throws up its colouring matter to the ſurface in form of ſcum, which is afterwards boiled down by itſelf to a due conſiſtence, and made up while ſoft into balls.

The annotto commonly met with among us is moderately hard, of a brown colour on the outſide, and a dull red within. It is difficultly acted upon by water, and tinges the liquor only of a pale browniſh yellow colour. In rectified ſpirit of wine it very readily diſſolves, and communicates a high orange or yellowiſh red. Hence it is uſed as an ingredient in varniſhes, for giving more or leſs of an orange caſt to the ſimple yellows. Alkaline ſalt renders it perfectly ſoluble in boiling water, without altering its colour: wool or ſilk boiled in the ſolution acquire a deep but not very durable orange dye. Its colour is not changed by alum or by acids, any more than by alkalis; but when imbibed in cloth, it is diſcharged by ſope, and deſtroyed by expoſure to the air.

Labat informs us, that the Indians prepare an annotto greatly ſuperior to that which is brought to us, of a bright ſhining red colour, almoſt equal to carmine; that for this purpoſe, inſtead of ſteeping and fermenting the ſeeds in water, they rub them with the hands, previouſly dipped in oil, till the pellicles come off and are reduced into a clean paſte, which is ſcraped off from the hands with a knife, and laid on a clean leaf in the ſhade to dry. De Laet, in his notes on Margrave's Natural

Hiſtory of Braſil, mentions alſo two kinds of annotto; one of a permanent crimſon colour (Coccineus), uſed as a fucus; and another, which gives a colour inclining more to that of ſaffron. This laſt, which is our annotto, he ſuppoſes to be a mixture of the firſt ſort with certain reſinous matters, and with the juice of the roots of the tree.—Ximenes relates, that annotto with urine ſtains linen of ſuch a permanent colour that is never to be waſhed out. Perhaps the firſt ſort is meant. Our annotto boiled in urine imparted to linen a deep yellowiſh red; the ſtained linen, hung out in the air in ſummer, in ſeven or eight days loſt all its colour, and became white again *.

ANTIMONY. The word antimony is always uſed in commerce to denote a metallic ore, conſiſting of ſulphur combined with the ſemi-metal which is uſually called regulus of antimony. But as it appears proper and convenient that the metallic ſubſtance itſelf ſhould be diſtinguiſhed by a ſimple term, inſtead of deriving its name from one of its ores, many chemical writers uſe the word antimony to denote the metallic ſubſtance or regulus, and in this acceptation it is uſed in the preſent article.

Antimony is of a ſilvery white colour, very brittle, and of a plated or ſcaly texture. Its ſpecific gravity is moderate. Soon after ignition it melts, and by a continuance of the heat it becomes calcined, and riſes in white fumes, which may afterwards be volatilized a ſecond time, or fuſed into a hyacinthine glaſs, according to the management of the heat: they are called argentine flowers of regulus of antimony. In cloſed veſſels, the regulus riſes totally without decompoſition. This metallic ſubſtance is not ſubject to ruſt by expoſure to air, though its ſurface becomes tarniſhed by that means. Its calces are ſoluble in water; and in that reſpect they reſemble the calx of arſenic, probably by an approach towards the acid ſtate.

Vitriolic acid, boiled upon the regulus of antimony, calcines the greater part, ſo as to render it inſoluble, the acid being at the ſame time decompoſed. Much vitriolic acid air eſcapes, and towards the end a ſmall quantity of ſulphur is ſublimed. By waſhing the reſidue in water, a vitriolic ſalt of antimony is ſeparated from the calx, which does not cryſtallize.

Nitrous acid very readily attacks antimony in the cold. Moſt part of the metal is calcined by this action; but a portion is diſſolved, and affords deliqueſcent cryſtals, decompoſable by heat. The calx of antimony formed by this acid is very white, and difficult of reduction.

Continued digeſtion is required for the ſolution of regulus of antimony in the marine acid. A conſiderable quantity is, however, at length diſſolved, which affords very deliqueſcent cryſtals. This ſalt melts by the application of heat, and is decompoſed by diſtilled water, in the ſame manner as the butter of antimony, from which it does not much differ.

Dephlogiſticated or aerated marine acid diſſolves the regulus of antimony with great facility.

Aqua regia, compoſed of ſeven parts nitrous and one marine acid, diſſolves it very readily, but lets fall a portion of white calx as it cools. The ſolvent power of either of the three ancient mineral acids on this ſemi-metal appears to be increaſed by mixture with any one of the others.

Earthy ſubſtances do not act on the regulus of antimony in the dry way. Its calx however enters readily into the compoſition of glaſs, to which it imparts more or leſs of an hyacinthine colour. When fuſed with vitriolated tartar it converts it partly

* Lewis on Neumann.

into

into hepar or liver of ſulphur, which diſſolves a portion of the calx of antimony; that is to ſay, the vital air of the acid calcines the regulus of antimony, while part of the acid becomes converted into ſulphur, either ſimply by the loſs of its vital air, or elſe by that loſs, together with the acquiſition of phlogiſton from the regulus.

Nitre detonates very readily with the regulus of antimony; when equal parts of theſe ſubſtances are projected into a red hot crucible, the reſidue of calx and alkali is known by the name of diaphoretic antimony. When the ſaline part is waſhed out by hot water, the reſidue is called waſhed diaphoretic antimony. The water uſed in the waſhing contains a portion of the calx ſuſpended by the alkali. This may be precipitated by the addition of an acid, and has been diſtinguiſhed by the name of ceruſe of antimony.

When regulus of antimony is pulverized, and accurately mixed with about twice its weight of corroſive ſublimate, a mutual action takes place with the production of heat; and if the mixture be diſtilled with a gentle fire, a thick fluid comes over, which congeals in the receiver, or in the neck of the retort, and is called butter of antimony. The reſidue conſiſts of revived mercury, and ſome regulus and calx of antimony. In this experiment, the dephlogiſticated marine acid combines with the antimony, while the mercury is revived, as may be eaſily explained on either of the two theories of chemiſtry. If the combination of regulus of antimony and ſulphur be uſed inſtead of the regulus itſelf, the mercury will be obtained in the form of cinnabar, at a much greater heat than is required to ſublime the butter of antimony.

When butter of antimony is thrown into pure water, an abundant white precipitate or calx falls down, which is a violent emetic, and is known by the name of powder of algaroth.

Nitrous acid diſſolves the butter of antimony. The ſolution, which does not appear to differ greatly from the ſolution of the regulus in aqua regia, ſoon depoſits a portion of calx. When an equal weight of nitrous acid has been three times diſtilled to dryneſs from butter of antimony, the reſidue, after ignition, is called bezoar mineral, and ſeems to be little more than a calx of the metal.

Sulphur combines very readily with the regulus of antimony, and forms a ſubſtance differing in no reſpect from the mineral or ore to which the name of antimony is excluſively appropriated. One part of ſulphur completely mineralizes four of the regulus.

Liver of ſulphur diſſolves the regulus of antimony, and affords an orange-coloured precipitate upon the addition of an acid.

Antimony, or the regulus combined with ſulphur, was a favourite object of reſearch in the experiments of the alchemiſts; in conſequence of which its properties are much better known than thoſe of the pure regulus. If this ſubſtance be heated, it melts, and a conſiderable portion of the ſulphur flies off, at the ſame time that the regulus becomes calcined, and riſes in white vapours. A gentler heat, leſs than is neceſſary to fuſe it, converts it into a grey calx; this calx contains a portion of ſulphur. If it be urged by a ſtronger heat, it melts into the form of glaſs, which is more or leſs tranſparent, according to the degree of calcination of the metal and the diſſipation of the ſulphur. When it contains much ſulphur, the glaſs is fuſible, opake, and of a dark red colour; whence it has been called liver of antimony.

When acids are applied to crude antimony, they diſſolve the regulus, and leave the ſulphur. The nitrous acid is beſt adapted to this ſolution.

Diaphoretic antimony is moſt commonly and advantageouſly prepared by detonating the crude antimony with nitre inſtead of the regulus; the only difference being,

that

that more nitre is required for the detonation, and that the reſidue contains vitriolated tartar as well as alkali and calx.

There are ſeveral preparations, conſiſting of combinations of antimony with an alkali, in which the proportions of the ingredients and the ſtate of the calx are very different, according to the nature and management of the proceſſes. Many of theſe have been highly praiſed in medicine, at the ſame time that they have been as ſtrongly exclaimed againſt for their ill effects. Both theſe aſſertions appear to have been well-founded. It is ſufficiently proved, that antimonial medicines have produced the happieſt effects, and are juſtly entitled to be conſidered as very powerful remedies; but, on the other hand, it is equally certain that their great efficacy muſt have required greater attention in their firſt exhibition than perhaps may have been paid; and the complicated nature of many of the proceſſes muſt have rendered it very difficult to produce ſubſtances poſſeſſing exactly the ſame properties, or proportion of component parts, at all times.

If antimony be treated with a fixed alkali, either by fuſion and ſubſequent ſolution in boiling water, or by ſimple ebullition, a precipitate is afforded by cooling, which is called kermes mineral, formerly uſed in medicine. It is thought to conſiſt of the calx of antimony in combination with a portion of ſulphur; but its component parts have not been accurately determined, and its properties differ according to the various methods uſed in preparing it.

The antimonial preparations moſt commonly uſed at preſent are, antimonial wine, and emetic tartar. Theſe, like every other preparation of this ſemi-metal, are prepared in a variety of ways. The wine may be had by infuſing pulverized glaſs of antimony in Spaniſh white wine for ſome days, and then filtering the clear fluid through paper. A very minute portion of the calx is taken up; and this is greater or leſs, according as the wine is more or leſs acid; and perhaps according to the temperature of the weather at the time of adminiſtering it. On this account it is found neceſſary to give this medicine cautiouſly, and by ſmall portions at a time, when it is intended that it ſhall act as an emetic. The emetic or antimoniated tartar of the London college is thus prepared:——Take of crude antimony and nitre equal parts, ſeparately reduced to powder, mix them, and inject them into a crucible heated to whiteneſs, that the mixture may melt after deflagration; pour it out, and reſerve the yellow maſs beneath the ſcoriæ, under the name of crocus of antimony; reduce this to a very ſubtle powder; boil it in water, and waſh the powder repeatedly in warm water till it becomes perfectly inſipid; then take equal parts, by weight, of the waſhed crocus of antimony and of cryſtals of tartar, and boil them together in three pints of water for every pound of the mixture, during half an hour; filter the liquor, and after due evaporation ſet it by to cryſtallize.—This is the antimoniated tartar. It is a triple ſalt, conſiſting of the acid of tartar, united to vegetable alkali, and antimony partially calcined, and is conſidered as a ſafe medicine, whoſe properties and effects are more conſtant and milder than moſt other antimonial remedies.

It has not been clearly determined on what circumſtances the medical effects of antimony depend. The ſaline preparations of mercury and other metals are ſuppoſed to derive their cauſticity from their tendency to become reduced to the metallic ſtate; in conſequence of which they corrode and decompoſe other combuſtible ſubſtances: but whether this be the caſe with antimony is doubtful. It appears neceſſary, however, that antimony ſhould be in the ſaline ſtate, in order that it may act upon the animal ſyſtem. When the regulus is made into thoſe ſmall

balls or pills, which, on account of the little change they undergo in paſſing through the human body, have been called perpetual pills, its purgative action is more or leſs violent according to the quantity of acid it meets with; and, in the preparations of this ſemi-metal, their effects ſeem likewiſe to be governed by the ſame circumſtance joined to their reſpective degrees of ſolubility. The nearly pure and inſoluble calx, produced by detonation with a large proportion of nitre, is almoſt ineffectual; whereas the more ſoluble calces or combinations are more or leſs active, according to their reſpective natures. Hence it appears to follow, that the ſimpleſt ſaline combinations are the moſt likely to produce effects conſtantly ſimilar; and that moſt of the calces and combinations, ſo highly extolled in the earlier age of chemiſtry, are attended with dangerous uncertainty in their operation.

Antimony combines with moſt other metallic ſubſtances, and produces mixtures whoſe properties have been attended to under their reſpective titles.

Antimony is found either native, in maſſes of the regulus, compoſed of ſhining irregular plates; or calciform, in white cryſtallized filaments; or combined with ſulphur, in the dark blueiſh or grey friable mineral called antimony, conſiſting moſt commonly of brilliant filaments diſpoſed parallel to each other; or, laſtly, combined with ſulphur and arſenic, in an ore which greatly reſembles the foregoing, except that it is of a red or reddiſh colour.

Native regulus of antimony, or its calx, may be aſſayed by nitrous acid, which diſſolves whatever arſenic it may contain, and only calcines the antimony. The ſulphureous antimonial ores are moſt conveniently analyzed by aqua regia, which takes up the calx, and leaves the ſulphur, which may be ſeparated by filtration. The remaining ſolvent may be examined with the uſual precipitants. In the dry way, antimony is ſeparated from its ſtony parts by fuſion in a moderate heat, nearly in the ſame manner as biſmuth, and may be reduced by ſlowly roaſting it, till it becomes converted into a grey calx, which may be briſkly fuſed with twice its weight of black flux.

Antimony and its regulus are chiefly uſed in medicine, and in ſome metallic alloys, ſuch as that uſed for printers' types, ſmall ſhot, &c.

ANTS. *See* ACID OF ANTS.

APPARATUS. As the whole of the practical part of chemiſtry conſiſts in placing bodies in contact with each other, ſo that they may exert their reſpective attractions or powers of combination without intermixture or diſturbance of other bodies not intended to enter the propoſed experiments, and alſo in raiſing or lowering the temperature of ſuch bodies under examination, it is evident that the degree of ſucceſs attending theſe reſearches muſt greatly depend upon the veſſels or apparatus made uſe of; and likewiſe that a great part of the terms in chemiſtry will be either deſcriptive of the apparatus, or of the operations performed with them. For this laſt reaſon, we ſhall here ſpeak of the proceſſes in a curſory way, at the ſame time that we deſcribe the apparatus.

Moſt operations that require an increaſe of temperature are performed by the communication of heat from bodies in combuſtion. But in ſeveral operations with bodies in the pneumatical way, the ſolar focus of a convex lens is uſed. The proceſſes which are performed by the ſimple application of heat are the following.

Roaſting. This conſiſts in expoſing mineral bodies to the heat of an open fire, for the purpoſe of diſſipating their volatile contents.

Calcination is performed by expoſing bodies, in an open veſſel, to ſtrong heat, till no farther change can be produced in them. The body which remains and

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withſtands the fire is called a calx. Both theſe terms are more particularly applied to metals. Such bodies as are very little changed by heat are called refractory.

Fuſion conſiſts in heating bodies in proper veſſels till they become fluid. It is chiefly uſed for the purpoſe of uniting ſmaller bodies into one large maſs, and caſting them into moulds of any deſired figure. The facility with which metals may be united in this way, after they have been divided, is probably the circumſtance that induced mankind to uſe them as the mediums of exchange, or ſigns of value of all other commodities.

Digeſtion conſiſts in keeping bodies for a conſiderable time immerſed in a fluid, at a higher temperature than that of the atmoſphere, in order that combinations may take place, which could not elſe have been effected.

Cementation is a proceſs wherein ſolid bodies, one or more of them being pulverized, are expoſed to heat in cloſed veſſels, with the intention that the more volatile parts of the one body may unite with the fixed part of the other.

Evaporation conſiſts in the diſſipating of fluids by heat.

Concentration conſiſts in increaſing the proportion of ſaline matter in any watery fluid, either by evaporating part of the water, or by cauſing it to freeze, and taking away the ice.

When evaporation is performed in veſſels either perfectly or nearly cloſed, ſo that the volatile parts, which are raiſed in one part of the apparatus, may be received and condenſed in the other parts, the proceſs is called diſtillation.

Rectification is a ſubſequent diſtillation of the product which comes over.

In the diſtillation of ſuch bodies as are ſolid, in the uſual temperature of the atmoſphere, the vapours are ſcarcely condenſed before they become ſolid again. In this caſe, the proceſs is called ſublimation, and the condenſed vapours, which uſually have a powdery form, are called flowers. Such are the flowers of brimſtone, of benjamin, of zinc, &c. Solid products obtained in this way are called ſublimates.

Some of theſe operations may be performed by a common culinary fire, and indeed moſt of them may, when the quantities of matter are ſmall, which is uſually the caſe in philoſophical experiments. In the arts, where every proceſs requires to be repeatedly carried on in the large way, a variety of furnaces have been contrived to ſuit the various intentions of the operators. But experimental enquiries demand the occaſional exertion of every branch of chemical operation; for which reaſon, the furnaces and apparatus ought to be conſtructed on as general principles as poſſible.

The veſſels uſed in chemiſtry are, fig. 1, crucibles or pots, made either of earth, black lead, forged iron, or platina. They are uſed for roaſting, calcination, and fuſion.

Fig. 2. Cucurbits, matraſſes, or bodies, which are glaſs, earthen, or metallic veſſels, uſually of the ſhape of an egg, and open at top. They ſerve the purpoſes of digeſtion, evaporation, &c.

Fig. 3. Retorts are globular veſſels of earthen ware, glaſs, or metal, with a neck bended on one ſide. Some retorts have another neck or opening at their upper part, through which they may be charged, and the opening may be afterwards cloſed with a ſtopper. Theſe are called tubulated retorts.

Fig. 4. Receivers are veſſels, uſually of glaſs, of a ſpherical form, with a ſtrait neck, into which the neck of the retort is uſually inſerted. When any proper ſub-

ſtance is put into a retort, and heated, its volatile parts paſs over into the receiver, where they are condenſed.

Fig. 5. The alembic is uſed for diſtillation, when the products are too volatile to admit of the uſe of the laſt-mentioned apparatus. The alembic conſiſts of a body A, to which is adapted a head B. The head is of a conical figure, and has its external circumference or baſe depreſſed lower than its neck, ſo that the vapours which riſe, and are condenſed againſt its ſides, run down into the circular channel formed by its depreſſed part, from whence they are conveyed by the noſe or beak C, into the receiver D. This inſtrument is leſs ſimple than the retort, which certainly may be uſed for the moſt volatile products, if care be taken to apply a gentle heat on ſuch occaſions. But the alembic has its conveniences. In particular, the reſidues of diſtillations may be eaſily cleared out of the body A; and in experiments of ſublimation, the head is very convenient to receive the dry products, while the more volatile and elaſtic parts paſs over into the receiver.

Fig. 6. Is the drawing of an alembic commonly made in metal. The head is contained in a veſſel of cold water, to accelerate the condenſation; a method which is not ſo rational as that of cooling the receiver, becauſe the coldneſs of the head in the former caſe cauſes much of the vapour to fall again into the body.

Fig. 7. Repreſents the large ſtills uſed in the diſtillation of ardent ſpirits. Inſtead of uſing a refrigeratory or receiver, the ſpirit is made to paſs through a ſpiral pipe called the worm, which is immerſed in a tub of cold water. During its paſſage it is condenſed, and comes out at the lower extremity, E, of the pipe, in a fluid form.

The beſt conſtruction of a furnace has not been well aſcertained from experience. There are facts which ſhew that a fire made on a grate near the bottom of a chimney, of equal width throughout, and open both above and below, will produce a more intenſe heat than any other furnace. What may be the limits for the height of the chimney is not aſcertained from any preciſe trials; but thirty times its diameter would not probably be too high. It ſeems to be a diſadvantage to contract the diameter of a chimney, ſo as to make it ſmaller than that of the fire-place, when no other air is to go up the chimney than what has paſſed through the fire; and there is no proſpect of advantage to be derived from widening it.

Fig. 8. Exhibits the common ſmall furnace for melting. A is the aſh-hole, where the air enters. C is the fire-place, containing a covered crucible-ſtand on a ſupport of baked earth, which reſts on the grate. D is the paſſage into E, the chimney. At D is a ſhallow crucible called a cupel, placed in the current of the flame, and at F is an earthen or ſtone cover, to be occaſionally taken off for the purpoſe of ſupplying the fire with fuel.

Fig. 9. Is the reverberatory furnace. A is the fire-place, B the dome and chimney, which is moveable. It ſerves to reflect the flames, and cauſes them to ſurround the veſſel C, which is by that means more ſtrongly heated than otherwiſe.

Charcoal is the material moſt commonly uſed in furnaces. It produces an intenſe heat without ſmoke, but it is conſumed very faſt. Coke or charred pit coal produces a very ſtrong and laſting heat. Neither of theſe produce a ſtrong heat at a diſtance from the fire. Where the action of flame is required, wood or coal muſt be burned. Several inconveniences attend the uſe of coal, as its fuliginous fumes, and its aptitude to ſtop the paſſage of air by becoming fuſed. It is uſed however in the reverberatory furnaces of glaſs-houſes, and is the beſt material where veſſels are to be ſupplied with a great quantity of heat at no great intenſity, ſuch as in diſtilleries, &c.

In many operations, where a moderate and regular heat is required, it is advantageous to uſe a bath, or to coat the veſſel intended to be heated. A chemical bath is uſually made by putting a quantity of water, ſand, or other fluid, or pulverulent ſubſtance, into a metallic veſſel or pot, and immerſing the diſtilling veſſel in it. When the water or ſand is once heated, it prevents the ſudden changes in the intenſity of the fire from affecting the veſſel that contains the matter under examination. Chemical baths are made with water, ſand, iron filings, mercury, and with the fuſible compoſition of eight parts biſmuth, five lead, and three tin, which becomes fluid with a leſs heat than that of boiling water.

Coating is chiefly intended to prevent glaſs veſſels from cracking by the ſudden variations of heat; and ſerves likewiſe to render them capable of preſerving their figure in higher degrees of heat than they could ſuſtain without it. The materials are clay and fine ſand, well worked together into a paſte, and with the addition of ſome hair, ſuch as the bricklayers uſe. This is laid upon the veſſel in ſucceſſive thin coatings.

The joints or cloſures of veſſels are made tight by compoſitions called lutes. The clay and ſand uſed for coating makes a very good lute. In the diſtillation of ſubſtances which are not corroſive, it is found convenient to cloſe the junctures with paper or linen paſted on. Wet ſtrips of bladder may alſo be uſed in theſe caſes. Slaked lime and the whites of eggs form a good lute, which dries and becomes firm; but the compoſition called fat lute is uſed when the vapours are of a corroſive and volatile nature. This is compoſed of clay, firſt made very dry and pulverized, and then beat together into a paſte with linſeed oil, which has been boiled upon litharge, and is known in the ſhops by the name of drying oil. Fat lute does not harden, but requires to be ſecured on its place by ſtrips of linen dipped in the lute made of lime and whites of eggs.

The flame of a lamp, with many ſmall wicks, may be uſed in diſtillations that require a low heat.

An ingenious ſtudent in chemiſtry, when he has familiarized himſelf with the firſt principles, will ſoon perceive that there are few philoſophical enquiries, if any, that require a large apparatus of furnaces or veſſels. A tobacco-pipe is a very uſeful crucible, in which a great number of operations may be performed in a common fire, eſpecially if urged with a pair of good double bellows. An earthen pot, or iron ladle, will contain a ſand-bath; and apothecaries phials, or Florence flaſks, ſerve very well for matraſſes. Chafing diſhes, or ſmall iron ſtoves, may be applied to ſerve many uſeful purpoſes. And the blow-pipe and ſpirit-lamp, with a ſet of ſmall retorts and receivers, may be adapted to the performance of almoſt every part of experimental chemiſtry.

The black-lead pots are very convenient for conſtructing a variety of moveable furnaces. They may be cut without difficulty by a ſaw whoſe teeth are ſet wide, and very eaſily admit of being ſcraped, drilled, or ground with ſand, to give them the requiſite figure. In Dr. Lewis's conſtruction, from whom the four following figures are taken, the pots which are intended to be applied to each other are ground flat upon a ſtone, with a little ſand, the holes are ſawed with the common compaſs-ſaw of the carpenters, and are made a little narrower externally than internally, by which means it is eaſy to fit them with ſtoppers made out of the broken pieces that may be bought where the pieces are ſold. Three or four hoops of copper-wire, about the thickneſs of a crow-quill, and firſt ſoftened by heating it red hot, are faſtened round the pots in the moſt convenient places, to render them more durable by keeping

their parts together, after they may have been cracked. A thin copper hoop ſerves to ſecure the place of junction of two pots.

Fig. 10. Repreſents a furnace for open fire formed by one pot. The lower ſquare aperture is the door of the aſh-pit, and the upper one the door of the fire-place, which in the intentions this furnace is deſigned for is kept ſhut. The charcoal is put in at the top, and ſupplied with air by one or more of the lower apertures, and the intenſity of the fire may in ſome meaſure be regulated by more or leſs cloſing of the apertures. If an iron pot, a ladle, or an old frying-pan, containing ſand, be put over this fire on three iron ſupporters, ſo as to leave room for the eſcape of the burned air from the fire, a bath will be formed, in which digeſtions, diſtillations, and other chemical operations, may be performed. The round hole in the bottom ſerves to inſert the nozle of a pair of bellows, which, when the other apertures are ſtopped, converts it into a blaſt furnace.

Fig. 11. Is a wind furnace, formed by two pots applied mouth to mouth. An iron chimney, compoſed of pieces by which its length may be regulated ſo as to increaſe the draft at pleaſure, is put on the top. The crucible containing the ſubject matters is placed upon a circular piece of brick laid upon the grate, which prevents the cold air from immediately ſtriking the crucible and endangering the breaking it. The charcoal is put through the fire-place door, or larger aperture of the dome, or upper pot, which ſhould always be cloſed immediately after each ſupply of fuel. The two oppoſite holes in the upper part of the dome afford the conveniency of paſſing an iron rod through, for ſafely and commodiouſly lifting it when intenſely heated.

Fig. 12. Is a furnace conſiſting of two pots, ſeparated by an iron hoop, in which an opening or door is cut. It ſerves for a reverberatory furnace for diſtilling with retorts of earthen-ware or coated glaſs. The bottom of the diſtilling veſſel reſts on two bars laid acroſs within the lower pot. If the grate of this furnace be occaſionally changed for a larger, which may be placed near the edge of the lower pot, a muffle, or ſmall earthen oven, may be placed in the midſt of the fire with its mouth oppoſite the hole in the iron hoop. In this may be performed all proceſſes that require the admiſſion of air and frequent inſpection, ſuch as aſſays, enamelling, &c.

Fig. 13. Is an improved blaſt furnace. The pot which contains the fuel for this purpoſe has a number of holes bored at ſmall diſtances, in ſpiral lines, all over it, from the bottom up to ſuch an height as it is deſigned the fuel ſhall reach. The crucible is placed upon a proper ſupport in the bottom, and the holes are made not in a perpendicular direction to it, but oblique, that the ſtreams of air forced in through them may but juſt touch it; by this means the crucible is in no danger of being cracked by the blaſt, and the impelled heat plays in a kind of ſpiral upon its ſurface. The lower pot receives this perforated pot to ſuch a depth that all its holes hang in the cavity, which cavity having no other outlet than the aperture for the bellows, the air blown in through this aperture neceſſarily diſtributes itſelf through the perforations of the inner pot. Both pots may be of the largeſt ſize, the external narrow part of the inner falling into the wide mouth of the outer. It wants no addition to its height; but, on the contrary, will be more commodious in regard to the inſpection and taking out of the crucible, if all the part above where the fuel reaches be ſawed away. The moſt convenient cover for it is an iron plate with a round hole in the middle, and a handle projecting at one ſide for lifting it. (Letter A.)

The force of the fire being thus in a great meaſure concentrated upon the crucible in the middle of the fuel, the crucible is heated expeditiouſly, and with a little quantity

quantity of fuel, to a very intenſe degree, while the exterior parts of the furnace are of no great heat, and permit the operator to approach without incommoding him.

Every effect of the moſt violent heat of furnaces may be produced by the flame of a candle or lamp, urged upon a ſmall particle of any ſubſtance, by the blow-pipe. This inſtrument is ſold by the ironmongers, and conſiſts merely of a braſs pipe about one eighth of an inch diameter at one end, and the other tapering to a much leſs ſize, with a very ſmall perforation for the wind to eſcape. The ſmaller end is bended on one ſide. For philoſophical or other nice purpoſes the blow-pipe is provided with a bowl or enlargement, B (fig. 14), in which the vapours of the breath are condenſed and detained, and alſo with three or four ſmall nozles, with different apertures, to be ſlipped on the ſmaller extremity. Theſe are of uſe when larger or ſmaller flames are to be occaſionally uſed, becauſe a larger flame requires a large aperture, in order that the air may effectually urge it upon the matter under examination.

There is an artifice in the blowing through this pipe, which is more difficult to deſcribe than to acquire. The effect intended to be produced is a continual ſtream of air for many minutes, if neceſſary, without ceaſing. This is done by applying the tongue to the roof of the mouth, ſo as to interrupt the communication between the mouth and the paſſage of the noſtrils; by which means the operator is at liberty to breathe through the noſtrils, at the ſame time that by the muſcles of the lips he forces a continual ſtream of air from the anterior part of the mouth through the blow-pipe. When the mouth begins to be empty, it is repleniſhed by the lungs in an inſtant, while the tongue is withdrawn from the roof of the mouth, and replaced again in the ſame manner as in pronouncing the monoſyllable tut. In this way the ſtream may be continued for a long time without any fatigue, if the flame be not urged too impetuouſly, and even in this caſe no other fatigue is felt than that of the muſcles of the lips.

A wax candle of a moderate ſize, but thicker wick than they are uſually made with, is the moſt convenient for occaſional experiments; but a tallow candle will do very well. The candle ſhould be ſnuffed rather ſhort, and the wick turned on one ſide towards the object, ſo that a part of it ſhould lie horizontally. The ſtream of air muſt be blown along this horizontal part, as near as may be without ſtriking the wick. If the flame be ragged and irregular, it is a proof that the hole is not round or ſmooth; and if the flame have a cavity through it, the aperture of the pipe is too large. When the hole is of a proper figure and duly proportioned, the flame conſiſts of a neat luminous blue cone, ſurrounded by another flame of a more faint and indiſtinct appearance. The ſtrongeſt heat is at the point of the inner flame.

The body intended to be acted on by the blow-pipe ought not to exceed the ſize of a pepper-corn. It may be laid upon a piece of cloſe-grained well-burned charcoal, unleſs it be of ſuch a nature as to ſink into the pores of that ſubſtance, or to have its properties affected by its inflammable quality. Such bodies may be placed in a ſmall ſpoon made of pure gold or ſilver, or platina.

Many advantages may be derived from the uſe of this ſimple and valuable inſtrument. Its ſmallneſs, which renders it ſuitable to the pocket, is no inconſiderable recommendation. The moſt expenſive materials, and the minuteſt ſpecimens of bodies, may be uſed in theſe experiments, and the whole proceſs, inſtead of being carried on in an opake veſſel, is under the eye of the obſerver from beginning to end. It is true, that very little can be determined in this way concerning the quantities of products; but, in moſt caſes, a knowledge of the contents of any ſubſtance

ſtance is a great acquiſition, which is thus obtained in a very ſhort time, and will at all events ſerve to ſhew the beſt and leaſt expenſive way of conducting proceſſes with the ſame matters in the larger way.

The blow-pipe has deſervedly of late years been conſidered as an eſſential inſtrument in a chemical laboratory, and ſeveral attempts have been made to facilitate its uſe by the addition of bellows, or ſome other equivalent inſtruments. Theſe are doubtleſs very convenient, though they render it leſs portable for mineralogical reſearches. It will not, here, be neceſſary to enter into any deſcription of a pair of double bellows fixed under a table, and communicating with a blow-pipe which paſſes through the table. Smaller bellows, of a portable ſize for the pocket, have been made for the ſame purpoſe. The ingenious chemiſt will find no great difficulty in adapting a bladder to the blow-pipe, which, under the preſſure of a board, may produce a conſtant ſtream of air, and may be repleniſhed, as it becomes empty, by blowing into it with bellows, or the mouth, at another aperture furniſhed with a valve opening inwards.

The chief advantage theſe contrivances have over the common blow-pipe is, that they may be filled with vital or dephlogiſticated air, which increaſes the activity of combuſtion to an aſtoniſhing degree. For the various habitudes of bodies when examined by the blow-pipe, *ſee* BLOW-PIPE.

Little need be ſaid concerning the manner of making experiments with fluid bodies in the common temperature of the atmoſphere. Baſons, cups, phials, matraſſes, and other ſimilar veſſels, form the whole apparatus required for the purpoſe of containing the matters intended to be put together, and no other precaution or inſtruction is required than to uſe a veſſel of ſuch materials as ſhall not be corroded or acted upon by its contents, and of ſufficient capacity to admit of any ſudden expanſion or frothing of the fluid, if expected. This veſſel muſt be placed in a current of air, if noxious fumes ariſe, in order that theſe may be blown from the operation.

The method of making experiments with permanently elaſtic fluids, or air, though ſimple, is not ſo obvious. We live immerſed in an atmoſphere not greatly differing in denſity from theſe fluids, which are not for that reaſon ſufficiently ponderous to be detained in open veſſels by their weight. Their remarkable levity, however, affords a method of confining them by means of other denſer fluids. Dr. Prieſtley, whoſe labours have ſo far exceeded thoſe of his predeceſſors and cotemporaries, both in extent and importance, that he may with juſtice be ſtyled the father of this important branch of natural philoſophy, uſes the following apparatus.

Fig. 15. A repreſents a wooden veſſel or tub; K, K, K, is a ſhelf fixed in the tub. When this apparatus is uſed, the tub is to be filled with water to ſuch an height as to riſe about one inch above the upper ſurface of the ſhelf. B, G, F, are glaſs jars inverted with their mouths downwards, which reſt upon the ſhelf. If theſe, or any other veſſels open only at one end, be plunged under the water, and inverted after they are filled, they will remain full, notwithſtanding their being raiſed out of the water, provided their mouths be kept immerſed: for in this caſe, the water is ſuſtained by the preſſure of the atmoſphere, in the ſame manner as the mercury in the barometer. It may without difficulty be imagined, that if common air, or any other fluid reſembling common air in lightneſs and elaſticity, be ſuffered to enter theſe veſſels, it will riſe to the upper part, and the ſurface of the water will ſubſide. If a bottle, a cup, or any other veſſel, in that ſtate which is uſually called empty, though really full of air, be plunged into the water with its mouth downwards, ſcarce any water will enter, becauſe its entrance is oppoſed by the elaſticity of the included air;

air; but if the veſſel be turned up, it immediately fills, and the air riſes in one or more bubbles to the ſurface. Suppoſe this operation to be performed under one of the jars which are filled with water, the air will aſcend as before; but, inſtead of eſcaping, it will be detained in the upper part of the jar. In this manner, therefore, we ſee that air may be emptied out of one veſſel into another by an inverted pouring, in which the air is made to aſcend from the lower to the upper veſſel, in which the experiments are performed, by the action of the weightier fluid, exactly ſimilar to the common pouring of denſer fluids, detained in the bottoms of open veſſels, by the ſimple action of gravity. When the receiving veſſel has a narrow neck, the air may be poured through a glaſs funnel, H.

C (fig. 15) is a glaſs body or bottle, whoſe bottom is blown very thin, that it may ſupport the heat of a candle ſuddenly applied, without cracking. In its neck is fitted, by grinding, a tube D, curved neatly in the form of the letter S. This kind of veſſel is very uſeful in various chemical operations, for which it will be convenient to have them of ſeveral ſizes. In the figure, the body C is repreſented as containing a fluid, in the act of combining with a ſubſtance that gives out air, which paſſes through the tube into the jar B, under whoſe mouth the other extremity of the tube is placed. At E is a ſmall retort of glaſs or earthen-ware, whoſe neck being plunged in the water, beneath the jar F, is ſuppoſed to emit the elaſtic fluid, extricated from the contents of the retort, which is received in the jar.

When any thing, as a gallipot, is to be ſupported at a conſiderable height within a jar, it is convenient to have ſuch wire ſtands as are repreſented fig. 16. Theſe anſwer better than any other, becauſe they take up but little room, and are eaſily bended to any figure or height.

In order to expel air from ſolid ſubſtances by means of heat, a gun-barrel, with the touch-hole ſcrewed up and rivetted, may be uſed inſtead of an iron retort. The ſubject may be placed in the chamber of the barrel, and the reſt of the bore may be filled with dry ſand, that has been well burned, to expel whatever air it might have contained. The ſtem of a tobacco-pipe, or a ſmall glaſs tube, being luted in the orifice of the barrel, the other extremity muſt be put into the fire, that the heat may expel the air from its contents. This air will of courſe paſs through the tube, and may be received under an inverted veſſel, in the uſual manner.

But the moſt accurate method of procuring air from ſeveral ſubſtances by means of heat, is to put them, if they will bear it, into phials full of quickſilver, with the mouths inverted in the ſame, and then throw the focus of a burning lens or mirror upon them. For this purpoſe, their bottoms ſhould be round and very thin, that they may not be liable to fly with the ſudden application of heat. The body C anſwers this purpoſe very well.

Many kinds of air combine with water, and therefore require to be treated in an apparatus in which quickſilver is made uſe of. This fluid being very ponderous, and of conſiderable price, it is an object of convenience as well as economy, that the trough and veſſels ſhould be ſmaller than when water is uſed.

When trial is to be made of any kind of air, whether it be fit for maintaining combuſtion, the air may be put in a long narrow glaſs veſſel, whoſe mouth being carefully covered, may be turned upward. A bit of wax candle being then faſtened to the end of a wire, which is bended ſo that the flame of the candle may be uppermoſt, is to be let down into the veſſel, which muſt be kept covered till the inſtant of plunging the lighted candle in the air.

Where the change of dimenſions, which follows from the mixture of ſeveral kinds of air, is to be aſcertained, a graduated narrow cylindrical veſſel may be made uſe

of. The graduations may be made by pouring in ſucceſſive equal meaſures of water into this veſſel, and marking its ſurface at each addition. The meaſure may be afterwards uſed for the different kinds of air, and the change of dimenſions will be ſhewn by riſe or fall of the mercury or water in the graduated veſſel. The purity of common air being determinable by the diminution produced by the addition of nitrous air, theſe tubes have been called eudiometer tubes. There are inſtruments called eudiometers, which conſiſt of an aſſemblage of parts adapted to the due mixture of theſe airs, and the accurate meaſurement of the change of bulk they undergo.

Some ſubſtances, more eſpecially powders, cannot conveniently be put in a phial, or paſſed through a fluid. When air is to be extricated from, or added to theſe, there is no better method than to place them on a ſtand under the receiver of the air-pump, and exhauſt the common air inſtead of excluding it by water or mercury. This proceſs requires a good air-pump and careful management, otherwiſe the common air will not be well excluded.

It is frequently an intereſting object to paſs the electric ſpark through different kinds of air, either alone or mixed together. In this caſe a metallic wire may be faſtened in the upper end of a tube, and the ſparks or ſhock may be paſſed through this wire to the mercury or water uſed to confine the air. If there be reaſon to apprehend that an expanſion in the air may remove the mercury or water beyond the ſtriking diſtance, another wire may be thruſt up to receive the electricity, or two wires may be cemented into oppoſite holes in the ſides of an hermetically ſealed tube. Holes may be made in glaſs, for this and other chemical uſes, by a drill of copper or ſoft iron, with emery and water; and where this inſtrument is wanting, a ſmall round file with water will cut a notch in ſmall veſſels, ſuch as phials or tubes, though with ſome danger of breaking them. In ſome electrical experiments of the kind here mentioned, there is reaſon to expect a fallacious reſult from the wires being burned by the exploſion or ſpark. For this reaſon, the electricity may be made to paſs through the legs of a ſyphon, containing the air which is under conſideration in the upper part of its curvature. One of the veſſels, in which the legs of the ſyphon reſt, muſt therefore be inſulated; and if any watery fluid be uſed to confine the air, it is generally ſuppoſed that no combuſtion takes place.

The proceſs of impregnating water with any aerial fluid it will combine with, does not require any particular apparatus, but may be performed with ſuch utenſils as are every where to be met with. The moſt uſual operation of this kind, is that of impregnating water with fixed air, which may be done in the following manner. The quart bottle C, fig. 17, is filled with water, and inverted into the baſon F, which likewiſe contains a little water. The inverſion may be eaſily managed, without any of the contents of the bottle eſcaping, if its orifice be covered with a card, to be withdrawn after the immerſion. A is a half pint phial, into which broken pieces of marble or chalk are put; and upon them is poured as much water, rendered very acid by a mixture of oil of vitriol, as may fill the bottle two-thirds. B is a bladder, whoſe neck is tied faſt round a perforated cork of a tapering figure. After the effervescence of the chalk and the acid has begun, the cork is to be thruſt into the neck of the phial A; the bladder being previouſly emptied by preſſure. Fixed air will eſcape from the chalk, and inflate the bladder. When this laſt is full, it muſt be diſengaged from the bottle, and the bended tube E muſt be thruſt into the orifice of its cork. The aperture of the tube being then placed beneath the mouth of the bottle C, it is eaſy to diſcharge the aerial contents of the bladder by preſſure into this laſt. Agitation of the bottle C, without withdrawing its neck out of the water, increaſes the contact of the air and water, by dividing them into ſmall parts, and by

that

that means cauſes the abſorption to take place in a few ſeconds. Two or three repetitionsof th proceſs impregnates the water ſo fully, that it will abſorb no more in this way. The Pyrmont water is of this kind.

The uſe of the bladder in this operation is only to prevent any of the fluid contents of the bottle A from paſſing into the bottle C, which would happen in the violent ſtate of ebullition, if the tube E were to paſs directly from the bottle A to C. The manipulation is ſimpler if the bladder have two holes at its oppoſite ends, the one containing a cork, conſtantly kept in the neck of the bottle A, and the other faſtened round the tube E, which then remains conſtantly beneath the mouth of C, and the air is preſſed up as occaſion may demand. See fig. 18.

When habitual uſe is made of water impregnated with fixed air, the apparatus of Dr. Nooth is very effectual and convenient. It conſiſts of three glaſs veſſels (fig. 19). The lower veſſel C contains the efferveſcent materials; it has a ſmall orifice at D, ſtopped with a ground-ſtopper, at which an additional ſupply of either acid or water, or chalk, may be occaſionally introduced. The middle veſſel B is open, both above and below. Its inferior neck is fitted by grinding into the neck H of the lower veſſel. In the former is a glaſs valve, formed by two pieces of tube, and a lens, which is moveable, between them, as repreſented in fig. 20. This valve opens upwards, and ſuffers the air to paſs; but the water cannot return through the tubes, partly becauſe the orifice is capillary, and partly becauſe the flat lens covers the hole. The middle veſſel is furniſhed with a cock E, to draw off its contents. The upper veſſel A is fitted, by grinding, into the upper neck of the middle veſſel. Its inferior part conſiſts of a tube that paſſes almoſt as low as the centre of the middle veſſel. Its upper orifice is cloſed by a ground ſtopper F. When this apparatus is to be uſed, the efferveſcent materials are put into the lower veſſel, the middle veſſel is filled with pure water, and put in its place; and the upper veſſel is nearly ſtopped, and likewiſe put in its place. The conſequence is, that the fixed air paſſing through the valve at H, aſcends into the upper part of the middle veſſel B, where by its elaſticity it re-acts on the water, and forces part up the tube into the veſſel A; part of the common air, in this laſt, being compreſſed, and the reſt eſcaping by the ſtopper, which is made of a conical figure, that it may be eaſily raiſed. As more fixed air is extricated, more water riſes, till at length the water in the middle veſſel falls below the lower orifice of the tube. Fixed air then paſſes through the tube into the upper veſſel, and expels more of the common air by raiſing the ſtopper. In this ſituation the water in both veſſels being in contact with a body of fixed air, becomes ſtrongly impregnated with that fluid, after a certain time. This effect may be haſtened by taking off the middle and upper veſſels together, and agitating them.

The valve is the moſt defective part of this apparatus; for the capillary tube does not admit the air through, unleſs there be a conſiderable quantity condenſed in the lower veſſel; and the condenſation has in ſome inſtances burſt the veſſel.

Modern diſcoveries reſpecting bodies in the aeriform ſtate have produced ſeveral capital improvements in the veſſels uſed for diſtillation. It was common with the earlieſt chemiſts to make a ſmall hole in the upper part of their retorts, that the elaſtic vapours might eſcape, which would otherwiſe have burſt the veſſels. By this means they loſt a very conſiderable part of their products. Fig. 21 is an apparatus of veſſels, in which all the products may be examined. A is a matraſs which communicates with the receiver B, by a tube that reaches very near the bottom of the latter. The upper part of this receiver communicates in the ſame manner with the ſecond receiver C, by a tube reaching nearly to the bottom of C. In like manner C communicates with D, and from D proceeds a re-curved tube, which may be

inſerted beneath an inverted veſſel of water or mercury. It is evident, in this apparatus, that whatever volatile matter eſcapes from the veſſel A, by heat or otherwiſe, will either be condenſed in B, C, or D; and that the aerial products will paſs through the whole ſet, and through the re-curved tube, into the inverted veſſel. Theſe receivers may be more or leſs numerous according to circumſtances, and the volatile products may be condenſed in, or made to paſs through, water, oil, or any other fluids, placed in either of the receivers. The tubes may be either fitted in with cork and cement, or, which is better but more expenſive, by grinding. Small veſſels of this kind form a convenient interruption in the re-curved tube, paſſing from a bottle containing matters that give out air, as they are preferable in cloſeneſs and neatneſs to a bladder.

Fig. 22. Exhibits an improvement in the receiver in diſtillation by Mr. Woulfe. A is the retort; B an intermediate veſſel called an adopter, which is only occaſionally uſed; C the receiver, having two necks, one at D inſerted into a bottle, which receives the products which are uſually condenſed in the receivers, and the other at E, tranſmits the more volatile or aeriform products into a baſon G, containing water, beneath the ſurface of which the extremity of the neck E is plunged. It is obvious that this apparatus is more particularly uſeful when the products are ſuch as combine with the fluids in G, and would otherwiſe eſcape; and it is hardly neceſſary to obſerve, that a bottle, or other convenient veſſel, may be ſubſtituted inſtead of the baſon G.

It often happens in chemical proceſſes, from the irregularity of the heat, or from other circumſtances, that the condenſation is more rapid, in proportion to the ſupply of vapour, at ſome period of the ſame operation than at others. Whenever this takes place, the elaſticity of the vapours will not be equal to the external preſſure of the air; and if any orifice of the veſſels which are in other reſpects cloſed be plunged in water, or any other fluid, this laſt will be preſſed into the veſſels. The remedy for this inconvenience is, to plunge the neck of the veſſel to no greater depth in the water, than that the fall of the water in the receiving veſſel may leave the orifice open for the admiſſion of air, before the water has riſen high enough above the orifice to reach the contents of the veſſels. This effect is increaſed by making the neck large, in proportion to the diameter of the veſſel which contains the water. Thus, if the neck E be made large, and the water from the baſon G ſhould, by a rapid condenſation in C, be forced up the neck, the ſurface of the water in G will fall ſo much as to leave the lower orifice of E uncovered, before any conſiderable riſe can take place. The beſt remedy againſt abſorption, in fig. 21, is to inſert a ſmall tube through the cork of the firſt veſſel B, to reach nearly to its bottom. This will admit the outer air on ſuch occaſions, and prevent the contents of the exterior bottles from being driven back by the preſſure of the atmoſphere. This obſervation applies to all chemical veſſels, and is in no caſe more eſſential than when the neck of a ſimple retort is plunged in water contained in a receiver. *See* BALANCE, THERMOMETER, HEAT, DISTILLATION.

APPLES. *See* ACID OF APPLES.

APYROUS. Bodies which ſuſtain the action of a ſtrong heat for a conſiderable time without change of figure or other properties, have been called apyrous: but the word is ſeldom uſed in the art of chemiſtry; it is ſynonimous with the word refractory.

AQUA FORTIS. This name is given to a weak, and ſomewhat impure nirous acid, commonly uſed in the arts. It is uſually contaminated with a ſmall quantity of marine acid. The artiſts who uſe nitrous acid diſtinguiſh the common and leſs pure acid by the name of aqua fortis, and call the more concentrated acid, ſpirit

of

of nitre. This diſtinction appears to be of ſome utility, and is therefore not improperly retained by chemical writers. *See* ACID, NITROUS.

The manufacturers of ſope in France and elſewhere call their lixivium or ſopelees by the name of ſtrong water; and this name (eau forte) being conſequently uſed to denote the cauſtic alkali in recipes for dying and other proceſſes, has given riſe to ſeveral miſtakes.

AQUA MARINE, *or* AUGITES. A precious ſtone of a tranſparent green, blue colour, fuſible by the blow-pipe; it is nearly the ſame both in form and ſpecific gravity with the Peru emerald, and the chryſolite. Its ſpecific gravity is about 2,72, and its hardneſs nearly the ſame as that of quartz.

AQUA REGIA, *or* REGIS. This acid is compounded of a mixture of the nitrous and marine acids, the baſes of which, together with a certain proportion of vital air different from what originally exiſted in the two acids, become combined in a manner which has not been clearly explained. When one or two parts of pale concentrated nitrous acid are mixed with four of marine acid, an efferveſcence ſoon takes place, and dephlogiſticated marine acid flies off in the elaſtic form, at the ſame time that the mixture becomes of a deep red colour: it has obtained its name from its property of diſſolving gold, the royal metal of the alchemiſts, which is not perceptibly acted upon by either of the acids which compoſe it.

Aqua regia may be made by adding to nitrous acid any alkaline or earthy ſalt which contains the marine acid; for the affinity of the nitrous acid to the baſe being in moſt caſes ſtronger than the marine, this laſt is ſet at liberty, and conſequently the mixture, if the ſalt be not exceſſive in quantity, ſo as to engage the whole of the nitrous acid, will contain a certain portion of both acids at liberty. An aqua regia will therefore be produced, which is not eſſentially impaired with reſpect to common uſes by the portion of neutral ſalt ſuſpended in it. It is uſual to make aqua regia by diſſolving ſal ammoniac in about four times its weight of ſtrong nitrous acid; but the reſults of experiments muſt vary conſiderably according to the nature and proportions of the ingredients made uſe of.

The opinions and inferences of chemical writers reſpecting the nature of this mixed acid, are various. After the diſcovery of the dephlogiſticated marine acid, it was concluded that the nitrous acid performs the ſame office with reſpect to the marine as the manganeſe does; that is, in fact, that it either deprives the marine acid of phlogiſton, or affords vital air to combine with it, or anſwers both theſe purpoſes. This general ſuppoſition is not however without ſeveral difficulties. If the marine acid be enabled to calcine and diſſolve gold, becauſe it has been dephlogiſticated or aerated by the nitrous, it ſhould follow much more ſtrongly that the nitrous acid itſelf ſhould diſſolve that metal; whereas in fact it does not. And again, it has not been ſhewn how this dephlogiſticated acid, which is ſo volatile and ſo ſparingly ſoluble in water, is retained in the ſolution; not to mention that no component part of the nitrous acid is found to eſcape during the efferveſcence, except the vital air which enters into the compoſition of the gas which flies off. When the two acids are in due proportion, aqua regia muſt therefore conſiſt of marine acid and nitrous acid, which has an under-proportion of vital air, or is in the moſt fuming ſtate; or, in other words, it contains the two baſes of the acids, together with a leſs proportion of vital air than they poſſeſſed before mixture. But whether theſe principles combine, and form a compound acid, or in what other order they may be arranged, has not been experimentally determined, though the writings of chemiſts abound with conjectures upon this ſubject.

The combinations of earths and alkalis, and even of metals, with aqua regia have

not

not been well examined. It is not known whether two different kinds of ſalts are formed apart from each other, or whether a triple combination takes place, conſiſting of two acids united to one baſe. It appears, however, that in ſome caſes the reſult is one entire compound, and in others two ſeparate ones. *See* GOLD, PLATINA, and the other metals.

AQUA SECUNDA. This name is ſometimes given to an exceedingly diluted aqua fortis, uſed in the arts for cleaning the ſurface of metals, and ſome other bodies.

AQUA VITÆ. Ardent ſpirit of the firſt diſtillation has been diſtinguiſhed in commerce by this name. The diſtillers of malt and molaſſes ſpirits call it low wines.

AQUILA ALBA. One of the names given to the combination of marine acid and mercury in that ſtate which is more commonly known by the denomination of mercurius dulcis, or, leſs properly, calomel.

ARABIC, GUM. This is reckoned the pureſt of gums, and does not greatly differ from gum Senegal, vulgarly called gum ſeneca, which is ſuppoſed to be the ſtrongeſt, and is on that account, as well as its greater plenty and cheapneſs, moſtly uſed by callico printers and other manufacturers. The gums of the plum and the cherry tree have nearly the ſame qualities as gum arabic. All theſe ſubſtances facilitate the mixture of oils with water, and they are ſaid to ſuffer a decompoſition, or conſiderable change, by freezing, but of what nature has not been clearly explained.

ARABLE LANDS. It is a problem in chemiſtry, and by no means one of the leaſt importance to ſociety, to determine what are the requiſites which diſtinguiſh fruitful lands from ſuch as are leſs productive. Since vegetable ſubſtances evidently imbibe from the earth and ſurrounding atmoſphere, the principles of oils, mucilages, and other peculiar products only found in organized ſubſtances, it can ſcarcely be doubted but that manure, or the remains of other decayed organized ſubſtances, renders lands fruitful, by ſupplying theſe materials ready formed. It may happen, however, that the putrefactive proceſs in a conſiderable quantity of manure may be ſo effective as to overcome the vital powers, or deſtroy the organization of the plant; and on this account an exceſs of manure muſt be hurtful. In thoſe caſes wherein vegetation is performed without the preſence of any thing which may be called manure, it ſeems proper, as far as the few and imperfect lights of chemiſtry can ſerve to direct us, to aſcribe the growing or augmentation of vegetables to the decompoſition of water or the air of the atmoſphere, rather than to any conſiderable addition of earthy particles; more eſpecially, as it appears, from good experiments, that the earth in which vegetables grow ſuffers very little loſs of its weight in conſequence of their increaſe. From the indiſpenſable neceſſity of water in vegetation, it appears that this fluid either ſupplies the greateſt part of the maſs of vegetables, or is at leaſt the vehicle or medium by which aerial fluids are condenſed and conveyed into the vegetable ſubſtance; which leads to a concluſion, that, generally ſpeaking, thoſe earths which are the beſt adapted to imbibe and retain water, and at the ſame time admit the acceſs of air, are moſt fruitful. Sand or ſmall particles of ſiliceous earth are evidently the leaſt adapted to this purpoſe. Clays of conſiderable purity will be too ſtiff, impenetrable, and adheſive. Chalky or calcareous ſoils are not only hard and permanent, ſo as to be with conſiderable difficulty penetrated by the roots of vegetables, but are little adapted either to imbibe more water than they naturally poſſeſs, or to part with that they already have. Little need be ſaid of the ponderous and magneſian

magneſian earths, as they do not enter in any notable proportion as ingredients in ſoils.

If we might therefore overlook the preſence of ſaline and combuſtible matter, which are indeed neceſſary to fertility, and the latter of which is the cauſe of the dark colour of mould, our attention would be naturally directed to a mixture of the ſiliceous, calcareous, and argillaceous earths, that is to ſay, of ſand, chalk or lime, and clay. The firſt being totally inſoluble in water, can ſcarcely be expected to anſwer any other purpoſe than that of mechanically ſeparating the parts of the maſs, or at leaſt of rendering them more eaſily ſeparable by froſt and other atmoſpherical changes. The calcareous and argillaceous earths form the compoſition diſtinguiſhed by the name of marle, and this will vary in its properties according to the nature of its compoſition; the friability and ſolubility of the lime in water ſerving greatly to correct the bad effects of the mere clay, while this on the other hand produces a change of equal advantage in the chalk or lime. It may eaſily be apprehended that the preſence of vitriolic acid or other acidifiable ſubſtances, together with the acceſs of air, cannot but produce changes by combination with theſe two earths, which will be ſtill more conſiderable, and cannot indeed be followed by any conjectural reaſoning, though the little we know of the ſubject ſufficiently evinces the great utility of experiments in this department of chemical enquiry.

ARBOR DIANÆ. All bodies whatever, in their tranſition from the fluid to the ſolid ſtate, are diſpoſed to arrange themſelves in peculiar ſymmetrical figures. *See* CRYSTALLIZATION. When one body is precipitated from its ſolvent by the addition of another, the tranſition to ſolidity is uſually ſo quick that the parts have not time to arrange themſelves, excepting in ſuch minute maſſes as conſtitute the pulverulent form. When ſilver is diſſolved in nitrous acid, and mercury is added, the elective attraction between the mercury and the acid acts with ſuch a degree of ſlowneſs, that the ſilver in certain caſes is ſeparated in the form of a tree or ſhrub, which the earlier chemiſts in their uſual fanciful way called the tree of Diana. In this, as in all precipitations, there are a variety of concomitant circumſtances which influence the peculiar form, and, for this reaſon, one proceſs uſually ſucceeds better than another. Lemery directs, that an ounce of fine ſilver be diſſolved in a ſufficient quantity of pure and moderately ſtrong nitrous acid. This ſolution muſt then be mixed in a matraſs with about twenty ounces of diſtilled water; and laſtly, two ounces of mercury are to be added to the mixture, after which the whole muſt be ſuffered to remain at reſt. During a ſpace of about forty days, a kind of tree of ſilver will be formed on the ſurface of the mercury, with branches greatly reſembling a vegetable ſubſtance in its ramifications. Macquer affirms that this proceſs ſucceeds very well, but the following of Homberg is much ſhorter.

Make an amalgam without heat, of four drams of leaf ſilver, with two drams of mercury. Diſſolve this amalgam in four ounces, or a ſufficient quantity of pure nitrous acid of a moderate ſtrength; dilute this ſolution in about a pound and a half of diſtilled water, agitate the mixture, and preſerve it for uſe in a glaſs bottle with a ground ſtopper. When this preparation is to be uſed, the quantity of one ounce is put into a phial, and the ſize of a pea of an amalgam of gold or ſilver, as ſoft as butter, is to be added; after which the veſſel muſt be left at reſt: ſoon afterwards, ſmall filaments appear to iſſue out of the ball of amalgam, which quickly increaſe, and ſhoot out branches in the form of ſhrubs.

In the above experiment of Lemery, the nitrous acid depoſits its ſilver, at the ſame time that it takes up mercury; and, in conſequence of the liquor being ſo much diluted, the proceſs goes on ſlowly, and the precipitated ſilver has time to arrange itſelf

according to the laws of its cryſtallization, whether that depend on the polarity of its particles, or on any other property not yet explained. In the proceſs of Homberg, there are two circumſtances which appear calculated to forward the proceſs: in the firſt place, the nitrous acid already contains mercury in ſolution, which may probably render it more diſpoſed to part with the ſilver; and in the next place, the mercury is combined with ſilver or gold in the form of an amalgam. Theſe may, perhaps, facilitate the precipitation of the ſilver, by preſenting a baſe for it to combine with, which may be more perfectly at repoſe, becauſe leſs agitable than the fluid mercury in the former experiment. After all, however, though the general theory of the experiment is not difficult, yet it does not ſeem eaſy to point out the effectual cauſe of the differences between the two reſults.

ARCANUM CORALLINUM. This name has been given to red precipitate, on which ſpirit of wine has been two or three times burnt, with an intention of rendering it milder. *See* PRECIPITATE, RED, or the article MERCURY.

ARCANUM DUPLICATUM. A name formerly given to the combination of vegetable alkali and vitriolic acid, and moſt commonly called vitriolated tartar.

ARCHIL, ARCHILLA, ROCELLA, ORSEILLE. A whitiſh moſs growing upon rocks in the Canary and Cape Verd iſlands, which yields a rich purple tincture, fugitive indeed, but extremely beautiful. This weed is imported to us as it is gathered: thoſe who prepare it for the uſe of the dyer, grind it betwixt ſtones, ſo as to thoroughly bruiſe, but not to reduce it into powder, and then moiſten it occaſionally with a ſtrong ſpirit of urine, or urine itſelf mixed with quicklime: in a few days it acquires a purpliſh red, and at length a blue colour; in the firſt ſtate it is called archil, in the latter, lacmus or litmus.

The dyers rarely employ this drug by itſelf, on account of its dearneſs and the periſhableneſs of its beauty. The chief uſe they make of it is for giving a bloom to other colours, as pinks, &c. This is effected by paſſing the dyed cloth or ſilk through hot water lightly impregnated with the archil. The bloom thus communicated ſoon decays upon expoſure to the air. Mr. Hellot informs us, that by the addition of a little ſolution of tin, this drug gives a durable dye; that its colour is at the ſame time changed towards a ſcarlet, and that it is the more permanent, in proportion as it recedes the more from its natural colour.

Prepared archil very readily gives out its colour to water, to volatile ſpirits, and to ſpirit of wine; it is the ſubſtance principally made uſe of for colouring the ſpirits of thermometers. As expoſure to the air deſtroys its colour upon cloth, the excluſion of the air produces a like effect in thoſe hermetically ſealed tubes, the ſpirits of large thermometers becoming in the compaſs of a few years colourleſs. M. l'Abbé Nollet obſerves (in the French Memoirs for the year 1742), that the colourleſs ſpirit, upon breaking the tube, ſoon reſumes its colour, and this for a number of times ſucceſſively; that a watery tincture of archil, included in the tubes of thermometers, loſt its colour in three days; and that in an open deep veſſel, it became colourleſs at the bottom, while the upper part retained its colour.

A ſolution of archil, in water, applied on cold marble, ſtains it of a beautiful violet or purpliſh blue colour, far more durable than the colour which it communicates to other bodies. M. Du Fay ſays, he has ſeen pieces of marble ſtained with it, which in two years had ſuffered no ſenſible change. It ſinks deep into the marble, ſometimes above an inch, and at the ſame time ſpreads upon the ſurface, unleſs the edges be bounded by wax or other like ſubſtances. It ſeems to make the marble ſomewhat more brittle.

Linnæus informs us, in the Swediſh Tranſactions for the year 1742, that the true archil moſs is to be found on the weſtern coaſts of England; and ſuſpects that there are ſeveral other more common moſſes, from which valuable colours might be extracted. A quantity of ſea moſs having rotted in heaps upon the ſhore, he obſerved the liquor in the heaps to look like blood; the ſea water, and the ſun, and the putrefaction having brought out the colour. M. Kalm, in an Appendix to Linnæus's Paper in the year 1745, mentions two ſorts of moſſes actually employed in ſome parts of Sweden for dying woollen red: one is the lichenoides coralliforme apicibus coccineis of Ray's Synopſis; the other, the lichenoides tartareum, farinaceum, ſcutellarum umbone fuſco of Dillenius. This laſt is a white ſubſtance, like meal clotted together, found on the ſides and tops of hills. It is ſhaved off from the rocks after rain, purified from the ſtony matters intermixed among it, by waſhing with water; then dried in the ſun, ground in mills, and again waſhed and dried: it is then put into a veſſel with urine, and ſet by for a month. A little of this tincture added to boiling water makes the dying liquor.—In the ſame Tranſactions, for the year 1754, there is an account of another moſs, which, prepared with urine, gives a beautiful and durable red or violet dye to wool and ſilk. This is the lichen foliaceus, umbilicatus ſubtus lacuneſus Linn. Flor. Suec. It grows upon rocks, and is readily diſtinguiſhed from others of that claſs, by its looking as if burnt or parched, conſiſting of leaves as thin as paper, convex all over on the upper ſide, with correſponding cavities underneath; adhering firmly to the ſtones by a little root under the leaves, and coming aſunder, when dry, as ſoon as touched. It is gathered after rain, as it then holds beſt together, and parts eaſieſt from the ſtone.

In France, a cruſtaceous moſs, growing upon rocks in Auvergne, is prepared with lime and urine, and employed by the dyers as a ſuccedaneum to the Canary archil, to which it is ſaid to be very little inferior: it is called Orſeille d'Auvergne, or Perelle. Mr. Hellot relates, that he has met with ſeveral other moſſes, which, on being prepared in the ſame manner, acquire the ſame colour. The moſt expeditious way, he ſays, of trying whether any moſs will yield an archil or not, is, to moiſten a little of it with a mixture of equal parts of ſpirit of ſal ammoniac and ſtrong lime-water, and add a ſmall proportion of crude ſal ammoniac. The glaſs is then to be tied over with a piece of bladder, and ſet by for three or four days. If the moſs is of the proper kind, the little liquor which runs from it upon inclining the veſſel, will appear of a deep crimſon colour; and this afterwards evaporating, the plant itſelf acquires the ſame colour.

Lewis *, from whom this article is taken, tried a good number of the common moſſes, both of the cruſtaceous and foliaceous kind, and not a few of the fungi; as alſo the herbs chamomile and milfoil, which yield a blue eſſential oil; and thyme, whoſe oil becomes blue by digeſtion with volatile ſpirits; but have not as yet met with any that yielded a colour like archil. Moſt of them gave a yellow or reddiſh brown tincture; and if there was a ſcarcity of other drugs for theſe kinds of dyes, ſome of the moſſes might be made to afford not inelegant ones. A few gave a deep red colour to the liquor; but when diluted it ſhewed a yellowiſh caſt, and when applied on cloth it gave only a yellowiſh red.

ARDENT SPIRIT. *See* SPIRIT, ARDENT, *or* OF WINE.

ARGILLACEOUS EARTH. *See* EARTHS.

ARMENUS LAPIS. ARMENIAN STONE. This is a ſoft blue ſtone, which does not admit of a poliſh, and conſiſts of calcareous earth, or gypſum, penetra-

* On Neumann, II. 241.

ting with the blue calx of copper. Hence it ſometimes effervesces with acids, and ſometimes not. It is too ſoft to give fire with ſteel, and loſes its colour when heated.

AROMA. The principle of ſmell in vegetables.

AROMATICS. Plants which poſſeſs a peculiar and remarkable ſmell are called aromatics. The principle of ſmell, or that upon which this property depends, was called Spiritus Rector by Boerhaave, and is by ſome chemiſts called Aroma. We poſſeſs little more than conjectures reſpecting this ſubſtance, which at all events appears to be of extreme ſubtilty. When plants are diſtilled by a gentle heat upon a water-bath, the principle of ſmell comes over, united either with the water or with the eſſential oil, of either of which it appears to compoſe an extremely ſmall part. Some plants may be diſtilled with ardent ſpirit to advantage, their fragrance uniting with this menſtruum.

From theſe and other circumſtances, the aromatic principle has been ſuppoſed to conſiſt of ſaline, oleaginous, or ſpirituous matter; and ſome have conjectured it to be a peculiar aëriform fluid, or gas, of very ſparing ſolubility in the ſeveral fluids that combine with it. On this occaſion we can only obſerve, that, notwithſtanding the rational proceeding of reaſoning from the facts we know to thoſe which ſtill remain to be inveſtigated, yet there are many experiments which muſt be made before we can pretend to ſpeak with accuracy upon this ſubject.

ARRACK. A ſpirituous liquor imported from the Eaſt Indies. It is chiefly manufactured at Batavia, and at Goa upon the Malabar coaſt. There are various accounts of the proceſſes and materials uſed in making it; and the diſagreement of theſe accounts ſeems to ariſe from the general appellation of *Arrack* being given, in the Eaſt Indies, to every kind of ſpirituous liquor; and alſo from the diſpoſition which the Dutch ſo eminently poſſeſs of endeavouring to keep their manufacturing proceſſes to themſelves. It is certain that the flavours of the ſeveral kinds of arrack differ as much from each other, as thoſe of brandy, rum, corn ſpirits, or any other of the ſpirituous liquors of Europe. The materials from which ardent ſpirit is diſtilled in the Eaſt Indies, are rice, melaſſes, and toddy, or the juice of the cocoa-nut tree. The Chineſe diſtil a ſpirit from rice, which they diſtinguiſh by the name of Sam-ſhu, and of which conſiderable quantities are exported to Batavia, for the purpoſe, as it is ſaid, of being converted into arrack by a ſecond diſtillation; though perhaps it may be conſumed among the numerous Chineſe who inhabit that city. The common Batavia arrack appears to be diſtilled from a mixture of the wort or infuſion of rice and the toddy, after both have paſſed through the vinous proceſs. And to theſe, according to circumſtances, it ſeems they add other ingredients, particularly ſpices.

Of European ſpirits the common malt ſpirit before rectification reſembles arrack the moſt. Arrack is reckoned leſs intoxicating than rum or brandy; but this difference ariſes from its being very ſeldom of equal ſtrength. Of five ſpecimens procured from different channels, I found the ſpecific gravity between 965 and 967, water being 1000; whence it follows that proof ſpirit lowered with about $\frac{3}{4}$ of its bulk of water, would have been of the ſame ſtrength as this arrack.

ARSENIC in the metallic ſtate, or the regulus of arſenic, is of a bright yellowiſh white colour, ſubject to tarniſh and grow black by expoſure to air. It is brittle, and when broken exhibits a laminated texture. In cloſe veſſels it ſublimes entire; but burns with a ſmall flame, if reſpirable air be preſent.

The arſenic met with in commerce has the form of white calx. It is brought chiefly from the cobalt works in Saxony, where zaffre is made. Cobalt ores contain much arſenic, which is driven off by long torrefaction. The ore is thrown into a furnace reſembling a baker's oven, with a flue, or horizontal chimney, nearly two hundred yards long, into which the fumes paſs, and are condenſed into a greyiſh or blackiſh powder. This is refined by a ſecond ſublimation in cloſe veſſels, with a little

little potaſh, to detain the impurities. As the heat is conſiderable, it melts the ſublimed flowers into thoſe cryſtalline maſſes which are met with in commerce.

The calx of arſenic is ſo far in the ſaline ſtate, as to be ſoluble in about eighty times its weight of water, at the temperature of 60°, or in fifteen times its weight of boiling water.

The regulus may be obtained from this calx, either by quickly fuſing it together with twice its weight of ſoft ſoap and an equal quantity of alkali, and pouring it out, when fuſed, into an hot iron cone; or by mixing it in powder with oil, and expoſing it in a mattraſs to a ſand heat. This proceſs is too offenſive to be made but in the open air, or where a current of air carries off the fumes. The decompoſed oil firſt riſes; and the regulus is afterwards ſublimed, in the form of a flaky metallic ſubſtance.

Vitriolic acid does not attack the regulus of arſenic, nor its calx, when cold; but, if it be boiled upon this ſemi-metal, vitriolic acid air is emitted, a ſmall quantity of ſulphur ſublimes, and the arſenic is reduced to the calciform ſtate. Boiling vitriolic acid diſſolves the calx of arſenic; but ſcarcely retains any portion of it when cold. The calx of arſenic is conſiderably leſs volatile when vitriolic acid is preſent or mixed with it; but it is ſaid that waſhing deprives it of the acid, and reſtores its properties.

Nitrous acid readily attacks and calcines the regulus of arſenic: it likewiſe diſſolves the calx of this ſemi-metal, in conſiderable quantities, by the aſſiſtance of heat; and affords a cryſtallized deliqueſcent ſalt by evaporation, which does not detonate on red-hot coals. The calx of arſenic is acidified by the action of nitrous acid diſtilled from it.

Boiling marine acid diſſolves the regulus, and alſo the calx, of arſenic; but affects it very little when cold. This ſolution affords precipitates upon the addition of alkalis.

The dephlogiſticated or aërated marine acid converts the calx of arſenic into arſenical acid.

The calx of arſenic acts, in many inſtances, like an acid. It decompoſes nitre by diſtillation; the nitrous acid flying off, and the arſenical ſalt of Macquer remaining behind. In this proceſs, the nitrous acid appears to acidify the calx. Quadrangular nitre is affected in the ſame manner. When the white calx of arſenic is diſtilled with ſulphur, volatile vitriolic acid flies off, and a combination of a yellow colour, called Orpiment, is produced; which appears to conſiſt of ſulphur united to regulus of arſenic: that is to ſay, part of the ſulphur receives vital air from the calx; to which, according to the ancient ſyſtem, it communicates phlogiſton; and in this manner the ſulphur becomes converted into vitriolic acid, while the arſenical calx is reduced, and combines with the reſt of the ſulphur. The combination of ſulphur and arſenic which has been fuſed is of a red colour, and known by the name of Realgal, or Realgar. Realgar appears to be leſs volatile than orpiment, or the yellow combination; for it remains at the bottom while the other ſublimes: but in what reſpect they differ from each other has not been well aſcertained. It is not improbable but that the orpiment may contain the calx in a more reduced ſtate than the realgar.

Saline liver of ſilver diſſolves the calx of arſenic, but more readily attacks the regulus.

Watery ſolutions of fixed alkalis diſſolve the calx of arſenic; and if they be loaded with it, by means of heat, a brown tenacious maſs is produced, which acquires ſolidity, has a diſagreeable ſmell, and is called Hepar of Arſenic. Mineral acids precipitate part of the arſenic; but a portion of it being acidified, adheres more tenaciouſly to the alkali. The acids occaſion no precipitation from the ſolution of arſenic in the

volatile alkali. It is not eaſy to explain what happens in this caſe without further experiments. The ſolutions of calx of arſenic in alkalis differ much in their properties from the combination which is produced when the nitrous ſalts are decompoſed by its means. This difference is accounted for from the conſideration that it is calx of arſenic in the firſt caſe, and the acid in the latter, which combines with the alkalis.

A ſolution of the calx of arſenic acts upon metals in the humid way, moſt probably in conſequence of its approach to the acid ſtate.

Regulus of arſenic is ſoluble in unctuous oil in a boiling heat: the ſolution is black, and has the conſiſtence of ſalve cold. Moſt metals unite with arſenic; which moſt probably exiſts in the reguline ſtate in ſuch as poſſeſs the metallic brilliancy. The calx, more or leſs acidified, is common in many minerals.

Arſenic is uſed in a variety of arts. It enters into metallic combinations wherein a white colour is required. Glaſs manufacturers uſe it; but its effect in the compoſition of glaſs does not ſeem to be clearly explained. Orpiment and realgar are uſed as pigments. Some attempts have been made to introduce it into medicine; but, as it is known to be a moſt violent poiſon, it is probable that the fear of its bad effects may long deprive ſociety of the advantages it might afford in this way. *See* ACID OF ARSENIC.

ARUM. The common ARUM, or Wakerobin, is a plant of extreme acrimony: the freſh root, ſlightly chewed, ſeems to burn and corrode the tongue; and oftentimes its pungent impreſſion continues for two or three days. The ſeat of this acrimony has hitherto eluded our enquiries: the diſtilled water and ſpirit have nothing of it, and the watery and ſpirituous extracts exceedingly little; and yet the root is by theſe operations deprived of it.

Greateſt part of the acrimony is deſtroyed by ſimple exſiccation; the dry root appears white and farinaceous, and affects the tongue but little. In this ſtate it is given medicinally for attenuating viſcid juices: formerly it was uſed as ſtarch for linen, before the diſcovery of that from wheat; and it is ſaid to have occaſioned a rawneſs and foreneſs of the hands very difficultly relievable by ointments. In ſome parts of France it is ſtill employed in bleaching; being ſuppoſed by its corroſive quality to diſſolve unctuoſities, and make the linen white.

From an ounce of the dry root Neumann obtained ſcarcely a ſcruple of ſpirituous extract: the ſame quantity yielded of watery extract near three drams. The firſt had ſome ſlight pungency; the latter none.

ASAFŒTIDA is obtained from a large umbelliferous plant growing in Perſia. The root reſembles a large parſnep externally, of a black colour: on cutting it tranſverſely, the aſafœtida exudes in form of a white thick juice, like cream; which, from expoſure to the air, becomes yellower and yellower, and at laſt of a dark brown colour. It is very apt to run into putrefaction; and hence thoſe who collect it, carefully defend it from the ſun. The freſh juice has an exceſſively ſtrong ſmell, which grows weaker and weaker upon keeping: a ſingle dram of the freſh fluid juice ſmells more than a hundred pounds of the dry aſafœtida brought to us. The Perſians are commonly obliged to hire ſhips on purpoſe for its carriage, as ſcarcely any one will receive it along with other commodities, its ſtench infecting every thing that comes near it.

The common aſafœtida of the ſhops is of a yellowiſh or browniſh colour, unctuous and tough, of an acrid or biting taſte, and a ſtrong diſagreeable ſmell, reſembling that of garlic. From four ounces Neumann obtained, by rectified ſpirit, two ounces ſix drams and a half of reſinous extract; and afterwards, by water, three drams half a ſcruple of gummy extract; about ſix drams and a ſcruple of earthy matter remaining undiſſolved. On applying water at firſt, he gained, from four ounces, one ounce three ſcruples and a half of gummy extract. The ſame quantity yielded, with ſtrong

French

French wine, two ounces and a half and fifteen grains; from which about one fifth may be deducted, for the ſolid matter contained in the wine. Schroder ſays that aſafœtida may be diſſolved over the fire, in water, vinegar, or wine; but only a part of it can be diſſolved in any of theſe liquors. The ſmell of the aſafœtida reſides wholly in an eſſential oil which ariſes in diſtillation both with water and ſpirit: four ounces, diſtilled with water, yielded about a dram of oil.

ASBESTOS, *or* ASBESTUS. The moſt obvious characters of the aſbeſtos are, a greater or leſs degree of flexibility, and their reſiſting the fire. The AMIANTHUS is often confounded with it. Cronſtedt diſtinguiſhes two kinds:—The aſbeſtos which is compoſed of ſoft and thin membranes, and is the amianthus of Wallerius. The membranes of this are either parallel, in which caſe he calls it Mountain Leather; or twiſted, which he diſtinguiſhes by the name of Mountain Cork. Both theſe kinds are white when pure; or of a yellowiſh brown when contaminated with iron. The impure ſort melts pretty eaſily into a black ſlag.—The ſecond kind of aſbeſtos diſtinguiſhed by Cronſtedt, has its fibres fine and flexible, and either parallel, of a light green or white colour; or of a greeniſh colour, ſomewhat more brittle, and contaminated with iron. This laſt is fuſible into a ſemi-tranſparent glaſs. There is alſo a light green martial aſbeſtos, with broken fibres, which belongs to this kind.

The ancients manufactured cloth out of the fibres of aſbeſtos, for the purpoſe, it is ſaid, of wrapping up the bodies of the dead, when expoſed on the funeral pile. Several moderns have likewiſe ſucceeded in making this cloth; the chief artifice of which ſeems to conſiſt in the admixture of flax and a liberal uſe of oil; both which ſubſtances are afterwards conſumed by expoſing the cloth for a certain time to a red heat. Although the cloth of aſbeſtos, when ſoiled, is reſtored to its primitive whiteneſs by heating in the fire; it is found nevertheleſs, by ſeveral authentic experiments, that its weight diminiſhes by ſuch treatment. The fibres of aſbeſtos, expoſed to the violent heat of the blow-pipe, exhibit ſlight indications of fuſion; though the parts, inſtead of running together, moulder away, and part fall down, while the reſt ſeem to diſappear before the current of air. Ignition impairs the flexibility of aſbeſtos in a ſlight degree.

According to Bergman, the fibrous aſbeſtos contains from 53 to 74 parts of ſiliceous earth, from 12 to 28 of mild magneſia, from 7 to 14 of mild calcareous earth, from 2 to 6 of clay, and from 1 to 10 of iron; the whole maſs being ſuppoſed to be divided into 100 parts. The martial aſbeſtos contains 62 of ſiliceous earth, 13,7 of magneſia, 12 of calcareous earth, 1,7 of clay, and 10,6 of iron. This affords a white ſlag by fuſion.

The mountain cork or leather contains in the hundred from 56 to 62 parts of ſiliceous earth, from 22 to 26 of mild magneſia, from 10 to 12 of mild calcareous earth, from 2 to near 3 of clay, and about 3 of iron.

ASHES. The fixed reſidue of combuſtible ſubſtances which remains after they have been burned, is called Aſhes. In chemiſtry it is moſt commonly uſed to denote the reſidue of vegetable combuſtion. Vegetable aſhes contain alkali, which may be waſhed out with water; and the inſoluble part is found to conſiſt of a calcareous earth for the moſt part, ſome clay, and a much leſs portion of magneſia. All theſe products vary in the different ſpecies of vegetables. Moſt plants afford likewiſe iron and manganeſe; and Mr. Sage, by experiments which have been verified by other chemiſts, has proved that gold is a very common ingredient, though in ſo ſmall a quantity as by no means to pay the charge of extracting it.

ASPHALTUM. This ſubſtance, likewiſe called Bitumen Judaicum, or Jews Pitch, is a ſmooth, hard, brittle, black or brown ſubſtance, which breaks with a poliſh, melts

melts eaſily when heated, and when pure burns without leaving any aſhes. It is found in a ſoft or liquid ſtate on the ſurface of the Dead Sea, but by age grows dry and hard. The ſame kind of bitumen is likewiſe found in the earth in other parts of the world; in China, America; and ſome parts of Europe, as the Carpathian hills, France, Neuchatel, &c. Its ſpecific gravity, according to Boyle, is 1400. Ardent ſpirit and ether act upon it but very ſlightly and partially. Water does not alter it; neither is it ſoluble in olive oil, or the eſſential oils of anniſeed or turpentine. According to Neumann, the aſphaltum of the ſhops is a very different compound from the native bitumen; and varies, of courſe, in its properties, according to the nature of the ingredients made uſe of in forming it. On this account, and probably from other reaſons, the uſe of aſphaltum, as an article of the materia medica, is almoſt totally laid aſide.

ASPIC. A plant which grows in plenty in Languedoc, in Provence, and eſpecially on the mountain of St. Baume in France. It is a kind of lavender, pretty much like that which grows in our gardens, both with regard to its flowers, which are blue, and to the figure and green colour of its leaves. The botaniſts call it male lavender, lavendula mas in Latin. They alſo give it other names, as ſpica nardi, pſeudo-nardus, &c. The oil of aſpic that painters, farriers, and other artificers uſe, which is likewiſe of ſome uſe in medicine, being employed in ſeveral Galenical compoſitions, is extracted from the flowers and ſmall leaves of this plant. It is very inflammable, and when once on fire it is almoſt impoſſible to extinguiſh it.

The true oil of aſpic is white, and of an aromatic ſcent. It is the only diſſolvent of ſandarac; by which means it may be eaſily diſtinguiſhed from that which is counterfeited, and which is nothing but oil of turpentine mixed with a little oil of petroleum.

In the above article, which is taken from Poſtlethwaite, the author, who refers to Savary as his authority, affirms that as ſandarac, or gum ſandarac, is very ſoluble in ſpirit of wine, he concludes that Mr. Savary is miſtaken, and muſt have meant karabé, or yellow amber. I find, in fact, that gum ſandarac, though it differs from reſins in ſeveral eſſential reſpects, particularly in not being ſoluble in olive oil, agrees with them nevertheleſs in this particular, that alcohol diſſolves it.

ASSAY, *or* ESSAY. This operation conſiſts in determining the quantity of valuable or precious metal contained in any mineral or metallic mixture, by analyſing a ſmall part thereof. The practical difference between the analyſis and the aſſay of an ore, conſiſts in this: The analyſis, if properly made, determines the nature and quantities of all the parts of the compound; whereas the object of the aſſay conſiſts in aſcertaining how much of the particular metal in queſtion may be contained in a certain determinate quantity of the material under examination. Thus, in the aſſay of gold or ſilver, the baſer metals are conſidered as of no value or conſequence; and the problem to be reſolved is ſimply, how much of each is contained in the ingot or piece of metal intended to be aſſayed. The examination of metallic ores may be ſeen under their reſpective titles; the preſent article will therefore conſiſt of an account of the aſſaying of gold and ſilver.

To obtain gold or ſilver in a ſtate of purity, or to aſcertain the quantity of alloy it may contain, it is expoſed to a ſtrong heat, together with lead, in a porous crucible. This operation is called cupellation, and is performed as follows: The precious metal is put, together with a due proportion of lead, into a ſhallow crucible, made of burned bones, called a cupel; and the fuſion of the metals is effected by expoſing them to a conſiderable heat in a muffel, or ſmall earthen oven, fixed in the midſt of a furnace. The lead continually vitrifies,

or

or becomes converted into a glaſſy calx, which diſſolves all the imperfect metals. This fluid glaſs, with its contents, ſoaks into the cupel, and leaves the precious metal in a ſtate of purity. During the cupellation, the ſcoriæ running down on all ſides of the metallic maſs, produce an appearance called circulation; by which the operator judges whether the proceſs is going on well. When the metal is nearly pure, certain priſmatic colours flaſh ſuddenly acroſs the ſurface of the globule, which ſoon afterwards appears very brilliant and clean: this is called the brightening, and ſhews that the ſeparation is ended.

After gold has paſſed the cupel, it may ſtill contain either of the other perfect metals, platina or ſilver. The former is ſeldom ſuſpected; the latter is ſeparated by the operations called quartation and parting. Quartation conſiſts in adding three parts of ſilver to the ſuppoſed gold, and fuſing them together; by which means the gold becomes one fourth of the maſs only. The intention of this is to ſeparate the particles of gold from each other, ſo that they may not cover and defend the ſilver from the action of the pure nitrous acid which is to be uſed in the proceſs of parting. Parting conſiſts in expoſing the maſs, previouſly hammered or rolled out thin, to the action of boiling aqua fortis of a due ſtrength. If the acid be not too concentrated, it diſſolves the ſilver, and leaves the gold in a porous maſs, of the original form; but, if too ſtrong, the gold is in a powdery form, which may be waſhed and dried. The weight of the original metal before cupellation, and in all the ſubſequent ſtages, ſerves to aſcertain the degree of fineneſs of the ingot, or ore, of which it is a part.

In eſtimating or expreſſing the fineneſs of gold, the whole maſs ſpoken of is ſuppoſed to weigh twenty-four carats of twelve grains each, either real, or merely proportional, like the aſſayers weights; and the pure gold is called fine. Thus if gold be ſaid to be 23 carats fine, it is to be underſtood that, in a maſs weighing 24 carats, the quantity of pure gold amounts to 23 carats.

In ſuch ſmall works as cannot be aſſayed by ſcraping off a part, and cupelling it, the aſſayers endeavour to aſcertain its quality, or fineneſs, by the touch. This is a method of comparing the colour, and other properties, of a minute portion of the metal, with thoſe of ſmall bars whoſe compoſition is known. Theſe bars are called touch-needles; and they are rubbed upon the black baſaltes, which for that reaſon is called the touch-ſtone. Black flint or pottery will ſerve the ſame purpoſe. Sets of golden needles may conſiſt of—Pure gold; pure gold $23\frac{1}{2}$ carats, with half a carat of ſilver; 23 carats of gold, with one carat ſilver; $22\frac{1}{2}$ carats gold, with $1\frac{1}{2}$ carat ſilver; and ſo forth, till the ſilver amounts to four carats; after which the additions may proceed by whole carats. Other needles may be made in the ſame manner, with copper inſtead of ſilver; and other ſets may have the addition conſiſting either of equal parts ſilver and copper, or ſuch proportions as the occaſions of buſineſs require.

In foreign countries, where trinkets and ſmall work are required to be ſubmitted to the aſſay of the touch, a variety of needles are neceſſary; but they are not much uſed in England. They afford, however, a degree of information which is more conſiderable than might at firſt be expected. The attentive aſſayer not only compares the colour of the ſtroke made upon the touch-ſtone, by the metal under examination, with that produced by his needle; but will likewiſe attend to the ſenſation of roughneſs, dryneſs, ſmoothneſs, or greaſineſs, which the texture of the rubbed metal excites, when abraded by the ſtone. When two ſtrokes perfectly alike in colour are made upon the ſtone, he may then wet them with aqua fortis, which will affect them very differently, if they be not ſimilar compoſitions; or the ſtone itſelf may be made red-hot by the fire, or by the blow-pipe, if thin black

pottery be uſed; in which caſe the phenomena of calcination will differ, according to the nature and quantity of the alloy.

The French government has from time to time cauſed various experimental enquiries to be made reſpecting the art of aſſaying gold, which have thrown much light on this ſubject, and greatly tend to produce uniformity in the reſults of the operation. The lateſt report on this ſubject may be ſeen in the Annales de Chimie, vol. vi. p. 64; which may be conſulted for a full account of the experiments and hiſtory of former proceedings. The general reſult is as follows, nearly in the words of the authors:

Six principal circumſtances appear to affect the operation of parting: namely, the quantity of acid uſed in parting, or in the firſt boiling; the concentration of this acid; the time employed in its application; the quantity of acid made uſe of in the repriſe, or ſecond operation; its concentration; and the time during which it is applied. From the experiments it has been ſhewn, that each of theſe unfavourable circumſtances might eaſily occaſion a loſs of from the half of a thirty-ſecond part of a carat to two thirty-ſecond parts. The writers explain their technical language by obſerving that, the whole maſs conſiſting of twenty-four carats, this thirty-ſecond part denotes $\frac{1}{768}$ part of the maſs. It may eaſily be conceived, therefore, that if the whole ſix circumſtances were to exiſt, and be productive of errors falling the ſame way, the loſs would be very conſiderable.

It therefore is indiſpenſably neceſſary that one uniform proceſs ſhould be followed in the aſſays of gold; and it is a matter of aſtoniſhment that ſuch an accurate proceſs ſhould not have been preſcribed by government for aſſayers in an operation of ſuch great commercial importance, inſtead of every one being left to follow his own judgment. The proceſs recommended in the report before us is as follows.

Twelve grains of the gold intended to be aſſayed muſt be mixed with thirty grains of fine ſilver, and cupelled with 108 grains * of lead. The cupellation muſt be carefully attended to, and all the imperfect buttons rejected. When the cupellation is ended, the button muſt be reduced by lamination into a plate of $1\frac{1}{2}$ inch, or rather more, in length, and four or five lines in breadth. This muſt be rolled up upon a quill, and placed in a mattraſs capable of holding about three ounces of liquid, when filled up to its narrow part. Two ounces and a half of very pure aqua fortis, of the ſtrength of 20 degrees of Baumé's areometer muſt then be poured upon it; and the mattraſs being placed upon hot aſhes, or ſand, the acid muſt be kept gently boiling for a quarter of an hour: the acid muſt then be cautiouſly decanted, and an additional quantity of $1\frac{1}{2}$ ounce muſt be poured on the metal, and ſlightly boiled for twelve minutes. This being likewiſe carefully decanted, the ſmall ſpiral piece of metal muſt be waſhed with filtered river-water, or diſtilled water, by filling the mattraſs with this fluid. The veſſel is then to be reverſed, by applying the extremity of its neck againſt the bottom of a crucible of fine earth, whoſe internal ſurface is very ſmooth. The annealing muſt then be made, after having ſeparated the portion of water which had fallen into the crucible; and, laſtly, the annealed gold muſt be weighed. For the certainty of this operation, two aſſays muſt be made in the ſame manner, together with a third aſſay upon gold of twenty-four carats, or upon gold whoſe fineneſs is perfectly and generally known.

* $1\frac{1}{2}$ gros. Though theſe doſes of ſilver and lead appeared to be proper for all operations of aſſaying gold, the commiſſaries obſerve, nevertheleſs, that gold of a lower title than eighteen carats may be alloyed with two parts, and even leſs, of ſilver; in order that the ſmall maſs of metal, when it comes to be laminated, may not be too thin, ſo as to break in pieces during the parting.

No concluſion muſt be drawn from this aſſay, unleſs the latter gold ſhould prove to be of the fineneſs of twenty-four carats exactly, or of its known degree of fineneſs; for, if there be either loſs or ſurplus, it may be inferred that the two other aſſays, having undergone the ſame operation, muſt be ſubject to the ſame error. The operation being made according to this proceſs, by ſeveral aſſayers, in circumſtances of importance, ſuch as thoſe which relate to large fabrications, the fineneſs of the gold muſt not be depended on, nor conſidered as accurately known, unleſs all the aſſayers have obtained an uniform reſult without communication with each other. The authors obſerve, however, that this identity muſt be conſidered as exiſting to the accuracy of half of the thirty-ſecond part of a carat. For, notwithſtanding every poſſible precaution or uniformity, it very ſeldom happens that an abſolute agreement is obtained between the different aſſays of one and the ſame ingot, becauſe the ingot itſelf may differ in its fineneſs in different parts of its maſs.

The aſſaying of ſilver does not differ from that of gold, excepting that the parting operation is not neceſſary. A certain ſmall portion of the ſilver is abſorbed by the cupel, and the more when a larger quantity of lead is uſed, unleſs the quantity of lead be exceſſive; in which caſe moſt of it will be ſcorified before it begins to act upon the ſilver. Meſſ. Hellot, Tillet, and Macquer, from their experiments made by order of the French Government, have aſcertained that four parts of lead are requiſite for ſilver of eleven pennyweights twelve grains fine; ſix parts of lead for ſilver of eleven pennyweights; eight parts lead for ſilver of ten pennyweights; ten parts lead for ſilver of nine pennyweights; and ſo on in the ſame progreſſion.

ASTRINGENT PRINCIPLE. The effect, called aſtringency, conſidered as diſtinguiſhable by the taſte, is incapable of being defined. It is perceived in the huſks of nuts, of walnuts, in green tea, and eminently in the nut gall; and moſt probably in all theſe is produced by the baſis of the acid of galls not perfectly acidified. If the nature and affinities of this ſubſtance were well aſcertained, it would probably tend to throw great light on the art of dying. *See* ACID OF GALLS.

ATHANOR. A kind of furnace, which has long ſince fallen into diſuſe. The very long and durable operations of the ancient chemiſts rendered it a deſirable requiſite, that their fires ſhould be conſtantly ſupplied with fuel in proportion to the conſumption. The athanor furnace was peculiarly adapted to this purpoſe. Beſides the uſual parts, it was provided with an hollow tower, into which charcoal was put. The upper part of the tower, when filled, was cloſely ſhut by a well-fitted cover; and the lower part communicated with the fire-place of the furnace. In conſequence of this diſpoſition, the charcoal ſubſided into the fire-place gradually as the conſumption made room for it; but that which was contained in the tower was defended from combuſtion by the excluſion of a proper ſupply of vital air.

ATMOSPHERE. *See* AIR ATMOSPHERICAL.

ATTRACTION. The inſtances of attraction which are exhibited by the phenomena around us are exceedingly numerous, and continually preſent themſelves to our obſervation. The effect of gravity, which cauſes the weight of bodies, is ſo univerſal, that we can ſcarcely form an idea how the univerſe could ſubſiſt without it. Other attractions, ſuch as thoſe of magnetiſm and electricity, are likewiſe obſervable; and every experiment in chemiſtry tends to ſhew that bodies are compoſed of various principles or ſubſtances, which adhere to each other with various degrees of force, and may be ſeparated by the known methods. It is a queſtion among philoſophers, whether all the attractions which obtain between bodies be referable to one general cauſe modified by circumſtances, or whether various original and diſtinct cauſes act upon the particles of bodies at one and the ſame time. The philoſophers at the beginning of the preſent century were diſpoſed to conſider the ſeveral attractions as eſ-

ſentially different, becauſe the laws of their action differ from each other; but the moderns appear diſpoſed to generalize this ſubject, and to conſider all the attractions which exiſt between bodies, or at leaſt thoſe which are permanent, as depending upon one and the ſame cauſe, whatever it may be, which regulates at once the motions of the immenſe bodies which circulate through the celeſtial ſpaces, and thoſe minute particles which are transferred from one combination to another in the operations of chemiſtry. The earlier philoſophers obſerved, for example, that the attraction of gravitation acts upon bodies with a force which is inverſely as the ſquares of the diſtances; and from mathematical deduction they have inferred, that the law of attraction between the particles themſelves follows the ſame ratio: but, when their obſervations were applied to bodies very near each other, or in contact, an adheſion took place, which is found to be much greater than could be deduced from that law applied to the centres of gravity. Hence they concluded, that the coheſive attraction is governed by a much higher ratio, and probably the cubes of the diſtances. The moderns, on the contrary, among whom are Bergmann, De Morveau, and others, have remarked that theſe deductions are too general, becauſe for the moſt part drawn from the conſideration of ſpherical bodies, which admit of no contact but ſuch as is indefinitely ſmall, and exert the ſame powers on each other, whichever ſide may be obverted. They remark likewiſe, that the conſequence depending on the ſum of the attractions in bodies not ſpherical, and at minute diſtances from each other, will not follow the inverted ratio of the ſquare of the diſtance taken from any point aſſumed as the centre of gravity, admitting the particles to be governed by that law; but that it will greatly differ, according to the ſides of the ſolid which are preſented to each other, and their reſpective diſtances; inſomuch that the attractions of certain particles indefinitely near each other will be indefinitely increaſed, though the ratio of the powers acting upon the remoter particles may continue nearly the ſame.

This doctrine, which however requires to be much more ſtrictly examined by the application of mathematical principles, obviouſly points to a variety of intereſting conſequences. The polarity of particles, or their diſpoſition to preſent themſelves in their approach to each other in certain aſpects, though it has been treated as a chimerical notion by a few ſuperficial writers, is one of the firſt of theſe reſults; and may be not unaptly ſhown by the experiment of floating bodies upon water, which depreſs the ſurface of that fluid, and form a cavity into which they ſubſide, and produce an appearance of attraction by ruſhing together; in which caſe their mode of application to each other is conſiderably governed by their figure, which cauſes them to turn round, and apply themſelves to each other in ſuch a manner as that the ſum of the forces that act upon the two bodies may be nearly in equilibrio.

As a proof that gravitation and chemical attraction are two diſtinct properties, inſtead of the latter being a modification of the former, it has been noticed that this laſt is not governed by the maſſes or ſpecific gravities of the particles. Thus, for example, ſince ſpirit of wine diſſolves reſin, and water does not; it would follow as an inference upon this ſyſtem, that the particles of the ſpirit are denſer than thoſe of the water; whereas the oppoſite concluſion might have been drawn, if the experiment had been made with gum inſtead of reſin; this ſubſtance being diſſolved by water, and not by ſpirit. Nevertheleſs, it is a good anſwer to this objection, that admitting the maſſes to govern the attractions, yet the modifications of figure may be ſuch as even to have a greater influence in the total effect than the maſs itſelf. Thus it may be conceived that two cubes of lead may adhere more ſtrongly by their flat ſurfaces than two ſpheres of gold, which cannot touch each other but in a point; and the ſuperiority of attraction in the one

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caſe over the other may prevail in all the ſmall diſtances to which chemical effects extend themſelves; not to mention that magnitude of particles will as greatly modify the conſequences as figure itſelf.

Theſe are ſpeculations which, with regard to the preſent ſtate of chemiſtry, ſtand in much the ſame ſituation as the theory of gravity, which is minutely deſcribed in Plutarch *, did with regard to aſtronomy before the time of Newton. As the celeſtial phenomena were formerly arranged from obſervation merely, but are now computed from the phyſical cauſe, gravitation; ſo, at preſent, chemiſtry is the ſcience of matter of fact duly arranged, without the aſſiſtance of any extenſive theory immediately deduced from the figures, volumes, denſities, or mutual actions of the particles of bodies. What it may hereafter be, muſt depend on the ability and reſearch of future chemiſts; but at preſent we muſt diſmiſs this remoter part of theory, to attend more immediately to the facts.

That the parts of bodies do attract each other, is evident from that adheſion which produces ſolidity, and requires a certain force to overcome it. For the ſake of perſpicuity, the various effects of attraction have been conſidered as different kinds of affinity, or powers. That power which phyſical writers call the attraction of coheſion, is generally called the attraction of aggregation by chemiſts. Aggregation is conſidered as the adheſion of parts of the ſame kind. Thus, a number of pieces of brimſtone united by fuſion form an aggregate, whoſe parts may be ſeparated again by mechanical means. Theſe parts have been called integrant parts: that is to ſay, the minuteſt parts into which a body can be divided, either really or by the imagination, ſo as not to change its nature, are called integrant parts. Thus, if ſulphur and an alkali be combined together, and form liver of ſulphur, we may conceive the maſs to be divided and ſubdivided to an extreme degree, until at length the maſs conſiſts of merely a particle of brimſtone and a particle of alkali. This then is an integrant part; and if it be divided further, the effect which chemiſts call decompoſition will take place; and the particles, conſiſting no longer of liver of ſulphur, but of ſulphur alone and alkali alone, will be what chemiſts call component parts or principles.

The union of bodies in a groſs way is called mixture. Thus, ſand and an alkali may be mixed together. But, when the very minute parts of a body unite with thoſe of another ſo intimately as to form a body which has properties different from thoſe of either of them, the union is called combination, or compoſition. Thus, if ſand and an alkali be expoſed to a ſtrong heat, the minute parts of the mixture combine, and form glaſs.

The earlier chemiſts were very deſirous of aſcertaining the firſt principles, or elements, of bodies; and they diſtinguiſhed by this name ſuch ſubſtances as their art was incapable of rendering more ſimple. They ſeem however to have overlooked the obvious circumſtance, that the limits of art are not the limits of nature. At preſent we hear little concerning elements. Thoſe ſubſtances which we have not hitherto been able to analyſe, or which, if decompoſed, have hitherto eluded the obſervation of chemiſts, are indeed conſidered as ſimple ſubſtances relative to the preſent ſtate of our knowledge, but in no other reſpect; for a variety of experiments give us reaſon to hope that future enquiries may elucidate their nature and compoſition. Some writers, calling thoſe ſimple ſubſtances by the name of Primary Principles, have diſtinguiſhed compounds of theſe by the name of Secondary Principles, which they ſuppoſe to enter again into combinations without decompoſition or change. It muſt be confeſſed, nevertheleſs, that no means have

* In his imperfect Treatiſe *De Facie in Orbe Lunæ.*

yet been deviſed to ſhew whether any ſuch ſubordination of principles exiſts. We may indeed diſcover that a compound body conſiſts of three or more principles; but whether two of theſe be previouſly united, ſo as to form a ſimple ſubſtance with relation to the third, or what in other reſpects may be their arrangement, we do not know.

If two ſolid bodies, diſpoſed to combine together, be brought into contact with each other, the particles which touch will combine, and form a compound; and if the temperature at which this new compound aſſumes the fluid form be higher than the temperature of the experiment, the proceſs will go no farther, becauſe this new compound being interpoſed between the two bodies will prevent their further acceſs to each other: but if, on the contrary, the freezing point of the compound be lower than this temperature, liquefaction will enſue; and the fluid particles being at liberty to arrange themſelves according to the law of their attractions, the proceſs will go on, and the whole maſs will gradually be converted into a new compound in the fluid ſtate. An inſtance of this may be exhibited by mixing common ſalt and perfectly dry pounded ice together. The cryſtals of the ſalt alone will not liquefy unleſs very much heated; the cryſtals of the water, that is to ſay, the ice, will not liquefy unleſs heated as high as thirty-two degrees of Fahrenheit; and we have of courſe ſuppoſed the temperature of the experiment to be lower than this, becauſe our water is in the ſolid ſtate. Now it is a well-known fact that brine, or the ſaturated ſolution of ſea-ſalt in water, cannot be frozen unleſs it be cooled thirty-eight degrees lower than the freezing point of pure water. It follows then, that if the temperature of the experiment be higher than this, the firſt combinations of ſalt and ice will produce a fluid brine, and the combination will proceed until the temperature of the maſs has gradually ſunk as low as the freezing point of brine; after which it would ceaſe, if it were not that ſurrounded bodies continually tend to raiſe the temperature. And accordingly it is found by experiment, that if the ice and the ſalt be previouſly cooled below the temperature of freezing brine, the combination and liquefaction will not take place. *See* HEAT.

The inſtances in which ſolid bodies thus combine together not being very numerous, and the fluidity which enſues immediately after the commencement of this kind of experiment, have induced ſeveral chemiſts to conſider fluidity in one or both of bodies applied to each other, to be a neceſſary circumſtance, in order that they may produce chemical action upon each other. *Corpora non agunt niſi ſint fluida.*

If one of two bodies applied to each other be fluid at the temperature of the experiment, its parts will ſucceſſively unite with the parts of the ſolid, which will by that means be ſuſpended in the fluid, and diſappear. Such a fluid is called a Solvent or Menſtruum; and the ſolid body is ſaid to be diſſolved.

Some ſubſtances unite together in all proportions. In this way the acids unite with water. But there are likewiſe many ſubſtances which cannot be diſſolved in a fluid at a ſettled temperature, in any quantity beyond a certain proportion. Thus, water will diſſolve only about one-fourth of its weight of common ſalt, and if more be added it will remain ſolid. A fluid which holds in ſolution as much of any ſubſtance as it can diſſolve, is ſaid to be ſaturated with it. But ſaturation with one ſubſtance is ſo far from preventing a fluid from diſſolving another body, that it very frequently happens that the ſolvent power of the compound exceeds that of the original fluid itſelf. Chemiſts likewiſe uſe the word Saturation in another ſenſe; in which it denotes ſuch an union of two bodies as produces a compound the moſt remote in its properties from the properties of the component parts themſelves.

ſelves. In other combinations, where one of the principles predominates, the other is ſaid to be ſuperſaturated, and the other principle is ſaid to be underſaturated.

Heat in general increaſes the ſolvent power of fluids, probably by preventing part of the diſſolved ſubſtance from congealing, or aſſuming the ſolid form.

It often happens, that bodies which have no tendency to unite are made to combine together by means of a third, which is then called the Medium. Thus, water and fat oils are made to unite, by the medium of an alkali, in the combination called Soap. Some writers, who ſeem deſirous of multiplying terms, call this tendency to unite the Affinity of Intermedium.

It very frequently happens, on the contrary, that the tendency of two bodies to unite, or remain in combination together, is weakened or deſtroyed by the addition of a third. Thus, ſpirit of wine unites with water in ſuch a manner as to ſeparate moſt ſalts from it. A ſtriking inſtance of this is ſeen in a ſaturated or ſtrong ſolution of nitre in water. If to this there be added an equal meaſure of ſtrong ardent ſpirit, the greateſt part of the nitre inſtantly falls down. Thus magneſia is ſeparated from a ſolution of Epſom ſalt by the addition of an alkali which combines with the vitriolic acid, and ſeparates the earth. The principle which falls down is ſaid to be precipitated, and in many inſtances is called a Precipitate. Some modern chemiſts uſe the term Precipitation in a more extended, and rather forced ſenſe; for they apply it to all ſubſtances thus ſeparated. In this enunciation therefore they would ſay, that the vegetable alkali precipitates the mineral alkali from a ſolution of common ſalt, though no viſible ſeparation or precipitation takes place; for the mineral alkali, when diſengaged from its acid, is ſtill ſuſpended in the water by reaſon of its ſolubility.

From an infinite number of facts of this nature it is clearly aſcertained, not as a probable hypotheſis, but as ſimple matter of fact, that ſome bodies have a ſtronger tendency to unite than others; and that the union of any ſubſtance with another will exclude, or ſeparate, a third ſubſtance which might have been previouſly united with one of them; excepting only in thoſe caſes wherein the new compound has a tendency to unite with that third ſubſtance, and form a triple compound. This preference of uniting, which a given ſubſtance is found to exhibit with regard to other bodies, is by an eaſy metaphor called Elective Attraction, and is ſubject to a variety of caſes, according to the number and the powers of the principles which are reſpectively preſented to each other. The caſes which have been moſt frequently obſerved by chemiſts, are thoſe called Simple Elective Attractions, and Double Elective Attractions.

When a ſimple ſubſtance is preſented or applied to another ſubſtance compounded of two principles, and unites with one of theſe two principles ſo as to ſeparate or exclude the other, this effect is ſaid to be produced by ſimple elective attraction.

It may be doubted whether any of our operations have been carried to this degree of ſimplicity. All the chemical principles we are acquainted with, are ſimple only with reſpect to our power of decompoſing them; and the daily diſcoveries of our cotemporaries tend to decompoſe thoſe ſubſtances which chemiſts a few years ago conſidered as ſimple. Without inſiſting however upon this difficulty, we may obſerve that water is concerned in all the operations which are called Humid; and beyond a doubt modifies all the effects of ſuch bodies as are ſuſpended in it. In the dry way, the element of fire, or matter of heat, admitted perhaps too raſhly by a very great number of chemiſts, tends equally to modify the effects of proceſſes in the

the dry way; and at all events, the variations of temperature, whether ariſing from an actual igneous fluid, or from a mere modification of the parts of bodies, tend greatly to diſturb the effects of elective attraction. Theſe cauſes render it difficult to point out an example of ſimple elective attraction, which may in ſtrictneſs be reckoned as ſuch. If however we overlook the effect of water, we may then point out various examples. Thus, as we have juſt obſerved, an alkali added to a ſolution of Epſom ſalt throws down the magneſia, and itſelf forms a ſalt of another kind in ſolution. So likewiſe, in the dry way, if a combination of lead and ſulphur be fuſed with iron, the ſulphur unites with this laſt, and leaves the lead free.

It will be obſerved however, that even in theſe inſtances the ſubſtances made uſe of are not univerſally admitted to be ſimple. All chemiſts now admit that the acids conſiſt of vital air united to a peculiar baſis in each; and lead, iron, and ſulphur are all ſuppoſed by the phlogiſtians to contain the principle of inflammability.

Double elective attraction takes place when two bodies, each conſiſting of two principles, are preſented to each other, and mutually change a principle of each; by which means two new bodies, or compounds, are produced of a different nature from the original compounds.

Under the ſame limitations as were pointed out in ſpeaking of ſimple elective attraction, we may offer inſtances of double elective attraction. Let mercury be diſſolved to ſaturation in the nitrous acid, the water will then contain a nitro-mercurial ſalt. Again, let vegetable alkali be diſſolved to ſaturation in the vitriolic acid, and the reſult will be a ſolution of vitriolated tartar. If mercury were added to the ſolution of vitriolated tartar, it would indeed tend to unite with the acid, but would produce no decompoſition; becauſe the elective attraction of the acid to the alkali is the ſtrongeſt. So likewiſe, if the nitrous acid alone be added to the ſolution of vitriolated tartar, its tendency to unite with the alkali, ſtrong as it is, will not effect any change, becauſe the alkali is already in combination with a ſtronger acid. But if the mercurial ſalt, or combination of mercury with nitrous acid, be added to the ſolution of vitriolated tartar, a change of principles will take place, the vitriolic acid will quit the alkali, and unite with the mercury, while the nitrous acid combines with the alkali; and theſe two new ſalts, namely Common Nitre, and the Vitriolic Salt of Mercury, may be obtained ſeparately by cryſtallization.

The moſt remarkable circumſtance in this proceſs is, that the joint effects of the attractions of the vitriolic acid to mercury, and the nitrous acid to alkali, prove to be ſtronger than the ſum of the attractions between the vitriolic acid and the alkali, and between the nitrous acid and the mercury; for, if the ſum of theſe two laſt had not been weaker, the original combinations would not have been broken. Mr. Kirwan, who firſt in the year 1782 conſidered this ſubject with that attention it deſerves, calls the affinities which tend to preſerve the original combinations, the Quieſcent Affinities. He diſtinguiſhes the affinities or attractions which tend to produce a change of principles, by the name of the Divellent Affinities. Some eminent chemiſts are diſpoſed to conſider as effects of double affinities thoſe changes of principles only which would not have taken place without the aſſiſtance of a fourth principle. Thus, the mutual decompoſition of Glauber's ſalt and common nitre, in which the alkalis are changed, and vitriolated tartar with quadrangular nitre are produced, is not conſidered by them as an inſtance of double decompoſition; becauſe the nitre would have been decompoſed by ſimple elective attraction, upon the addition of either of the two principles of the vitriolated tartar. But as there is no doubt that the two principles effect the decompoſition with much greater energy,

energy, and as this diſtinction does not appear to be of any uſe, it ſeems unneceſſary to inſiſt upon it.

There are various circumſtances which modify the effects of elective attraction, and have from time to time miſled chemiſts in their deductions. The chief of theſe is the temperature, which, acting differently upon the ſeveral parts of compounded bodies, ſeldom fails to alter, and frequently reverſes, the effects of the affinities. Thus, if ſpirit of wine be added to the ſolution of nitre, it unites with the water, and precipitates the ſalt at a common temperature. But if the temperature be raiſed, the ſpirit riſes on account of its volatility, and the ſalt is again diſſolved. Thus again, if vitriolic acid be added, in a common temperature, to a combination of phoſphoric acid and lime, it will decompoſe the ſalt, and diſengage the phoſphoric acid; but if this ſame mixture of theſe principles be expoſed to a conſiderable heat, the vitriolic acid will have its attraction to the alkali ſo much diminiſhed, that it will riſe, and give place again to the phoſphoric, which will combine with the lime. Again, mercury kept in a degree of heat very nearly equal to volatilizing it will abſorb vital air, and become converted into the red calx called Precipitate per ſe; but if the heat be augmented ſtill more, the vital air will aſſume the elaſtic ſtate, and fly off, leaving the mercury in its original ſtate. Numberleſs inſtances of the like nature continually preſent themſelves to the obſervation of chemiſts, which are ſufficient to eſtabliſh the concluſion, that the elective attractions are not conſtant but at one and the ſame temperature.

Many philoſophers are of opinion, that the variations produced by change of temperature ariſe from the elective attraction of the matter of heat itſelf. But there are no deciſive experiments either in confirmation or refutation of this hypotheſis.

If we except the operation of heat, which really produces a change in the elective attractions, we ſhall find that moſt of the other difficulties attending this ſubject ariſe from the imperfect ſtate of chemical ſcience. If to a compound of two principles a third be added, the effect of this muſt neceſſarily be different according to its quantity, and likewiſe according to the ſtate of ſaturation of the two principles of the compounded body. If the third principle which is added be in exceſs, it may diſſolve and ſuſpend the compound which may be newly formed, and likewiſe that which might have been precipitated. The metallic ſolutions, decompoſed by the addition of an alkali, afford no precipitate in various caſes when the alkali is in exceſs; becauſe this exceſs diſſolves the precipitate, which would elſe have fallen down. If, on the other hand, one of the two principles of the compound body be in exceſs, the addition of a third ſubſtance may combine with that exceſs, and leave a neutral ſubſtance, exhibiting very different properties from the former. Thus, if cream of tartar, which is a ſalt of difficult ſolubility, conſiſting of the vegetable alkali united to an exceſs of the acid of tartar, be diſſolved in water, and chalk be added, the exceſs unites with part of the lime of the chalk, and forms a ſcarcely ſoluble ſalt; and the neutral compound which remains after the privation of this exceſs of acid is a very ſoluble ſalt, greatly differing in taſte and properties from the cream of tartar. The metals and the acids likewiſe afford various phenomena, according to their degree of calcination or acidification. A determinate calcination is in general neceſſary for the ſolution of metals in acids; and the acids themſelves act very differently, accordingly as they are more or leſs acidified. Thus, the fuming nitrous acid gives place to acids which are weaker than the pale nitrous acid: the ſulphureous or volatile vitriolic acid gives place to acids greatly inferior in attractive power or affinity to the denſe vitriolic acid, or oil of vitriol. The de-

ception ariſing from effects of this nature is in a great meaſure produced by the want of diſcrimination on the part of chemical philoſophers; it being evident, that the properties of any compound ſubſtance depend as much upon the proportion of its ingredients, as upon their reſpective nature.

The ſolubility or inſolubility of principles, at the temperature of any experiment, has likewiſe tended to miſlead chemiſts of inferior accuracy, who have deduced conſequences from the firſt effects of their experiments. It is evident that many ſeparations may enſue without precipitation; becauſe this circumſtance does not take place unleſs the ſeparated principle be inſoluble, or nearly ſo. The mineral alkali cannot be precipitated from a ſolution of Glauber's ſalt by the addition of vegetable alkali, becauſe of its great ſolubility; but, on the contrary, the new compound itſelf, or vitriolated tartar, which is much leſs ſoluble, may fall down if there be not enough water preſent to ſuſpend it. No certain knowledge can therefore be derived from the appearance or the want of precipitation, unleſs the products be carefully examined. In ſome inſtances all the products remain ſuſpended, and in others they all fall down, as may be inſtanced in the decompoſition of martial vitriol by lime. Here the acid unites with the lime, and forms ſelenite, which is ſcarcely at all ſoluble; and the ſtill leſs ſoluble calx of iron, which was diſengaged, falls down along with it.

Many inſtances preſent themſelves, in which decompoſition does not take place, but a ſort of equilibrium affinity is perceived. Thus, the mineral alkali, added to cream of tartar, forms a triple ſalt by combining with its exceſs of acid. So likewiſe the volatile alkali combines with a portion of the acid of corroſive ſublimate, and forms the triple compound diſtinguiſhed by the barbarous name of Sal Alembroth.

When we reflect maturely upon all the circumſtances enumerated, or ſlightly touched upon, in the foregoing pages, we may form ſome idea of the extenſive field of reſearch which yet remains to be explored by chemiſts. If it were poſſible to procure ſimple ſubſtances, and combine two together, and to this combination of two to add one more of the other ſimple ſubſtances, the reſult of the experiment would in many caſes determine, by the excluſion of one of the three, that its affinity to either of the remaining two was leſs than that between thoſe two reſpectively. In this way it would be aſcertained, in the progreſs of experimental enquiry, that the ſimple attractions of a ſeries of ſubſtances were gradually increaſing or diminiſhing in ſtrength. Thus, the volatile alkali ſeparates clay from the vitriolic acid; magneſia, in like manner, ſeparates the volatile alkali; lime predominates, in the ſtrength of affinity, over magneſia, as appears by its ſeparating this laſt earth; the mineral alkali ſeparates the lime, and itſelf gives place to the vegetable alkali; and, laſtly, the vegetable alkali yields its acid to ponderous earth. The ſimple elective attractions of theſe ſeveral ſubſtances to vitriolic acid are therefore in the inverted order of their effects; ponderous earth is the ſtrongeſt; and this is ſucceeded regularly by the vegetable alkali, the mineral alkali, lime, magneſia, volatile alkali, and clay. It is evident that reſults of this nature, being tabulated, as was firſt done by the celebrated Geoffroy, and laſt of all by Bergmann, muſt afford a moſt valuable maſs of chemical knowledge. It muſt be remarked, however, that theſe reſults merely indicate that the powers are greater or leſs than each other; but how much greater or leſs is not determined, either abſolutely or relatively. Tables of this nature cannot therefore inform us of the effects which may take place in the way of double affinity, for want of the numerical relations between the attracting powers. Thus, when we are in poſſeſſion of

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the order of the ſimple elective attractions between the vitriolic acid and a ſeries of ſubſtances, and alſo between the nitrous acid and the ſame ſubſtances; and when, in addition to this, the reſpective powers of each of the acids upon every one of the ſubſtances ſingly taken, are known, ſo far as to determine which will diſplace the other—yet we cannot thence foretel the reſult of applying two combinations to each other, each containing an acid united with one of the number of ſimple ſubſtances. Or, more conciſely, a table of ſimple elective attractions can be of no uſe to determine the effects of double elective attraction, unleſs the abſolute power of the attractions be expreſſed by number inſtead of their order merely.

It appears therefore that the preſent ſtate of chemiſtry affords us no indication by which we may come at the reſults of double elective attraction without actual experiment; and, in this way, we may aſcertain, whenever a double decompoſition takes place, that the ſum of the attractions which tend to produce the new combinations is greater than the ſum of thoſe attractions which tend to preſerve the compounds in their original form. But as theſe attractions, in the ſimpleſt caſes, are four in number, and the effect may ariſe from an exceſs or defect of any one of the four, or may be diſtributed in an infinity of proportions among them, it muſt eaſily be ſeen how numerous the difficulties are which attend theſe reſearches, and what ample ſpace is left for exerciſing the ſagacity of philoſophers in chemical analyſis.

There have not been wanting a number of eminent philoſophers who have exerted themſelves in attempting to diſcover data by which the phenomena of chemiſtry might be ſubjected to computation; and though the difficulty of the ſubject has hitherto prevented any thing of a concluſive nature from being done, their reſearches have nevertheleſs thrown great light on the ſubject. Mr. de Morveau firſt attempted to aſcertain the proportional powers of attraction between mercury and other metals, by determining the quantity of weight or re-action neceſſary to ſeparate a metallic ſurface of known dimenſions from its contact with the face of this fluid. This method however cannot be extenſively applied in chemical purſuits. Mr. Wenzel, by a ſeries of experiments in which metallic cylinders of ſimilar dimenſions, coated on all ſides with a proper varniſh or covering excepting at the baſe, were expoſed to the action of nitrous acid, thought himſelf authorized to conclude that the affinities of bodies with a common ſolvent are inverſely in proportion to the time neceſſary for their ſolution; or, which is the ſame thing, directly in proportion to the quantities diſſolved in equal ſmall portions of time. It is very probable that this concluſion would prove true, if we could make our experiments with ſimple ſubſtances; but as this is not the caſe, his deduction cannot be applied to various fluids. For if we admit it to be true with regard to his experiments with the nitrous acid, it will not follow that his conſequences can be applied to the marine acid; becauſe a foreign circumſtance intervenes, and modifies the attractions. The nitrous acid is eaſily decompoſed, readily calcines metals, and ſpeedily diſſolves them when calcined. The marine acid appears to be ſcarcely, if at all, decompoſable in our experiments; and therefore acts ſlowly, and in ſome inſtances not at all, upon metallic ſubſtances. Yet from the true teſt of ſuperior affinity, namely, the decompoſing of compounds already formed, the attraction of the marine acid, ſlow as its effects are, often proves ſtronger than that of the nitrous, from which it ſeparates many metallic baſes. It may likewiſe be obſerved, even with regard to the nitrous acid, that the effects not being ſimple, are likewiſe modified by the attraction of the metal for vital air, or its diſpoſition

to part with phlogiſton; or in a word, to loſe ſight of the two theories, its diſpoſition to become calcined. On this account, though tin or antimony are very rapidly attacked by the nitrous acid; they give place, nevertheleſs, in the way of precipitation, to lead, which is much more ſlowly diſſolved. And accordingly it is found that Mr. Wenzel's numbers, expreſſive of the powers of attraction, do not agree with the real experiments of double affinity.

Mr. Kirwan, to whoſe extenſive reſearches the ſcience of chemiſtry is ſo greatly indebted, has attended with peculiar ſagacity to almoſt every attribute of chemical compounds, with a view to obtain that moſt deſirable acquiſition, the proportional ſtrength of affinity. His Papers, which were read to the Royal Society as early as the years 1781 and 1782, are ſtill of the higheſt value to chemiſts; though all the difficulties of the ſubject were far from being as well known at that period as they are at preſent. In conſequence of Dr. Prieſtley's diſcovery of the method of exhibiting the marine acid in the aëriform ſtate, he proceeded to infer the quantities of real acid correſponding with the various denſities or ſpecific gravities of the marine acid. From theſe data, proceeding upon the ſuppoſition that equal quantities of the nitrous and vitriolic acids were required to ſaturate the ſame quantity of fixed alkali as was ſaturated by the marine acid, he formed tables of the quantities of real acid contained in thoſe fluid acids, at different denſities. He proceeded to make experiments for aſcertaining the quantities of real acid (upon this ſuppoſition, together with an induction of the baſes and water) contained in the earthy and alkaline ſalts: after which he proceeded to enquire into the quantities of phlogiſton contained in the ſeveral kinds of air, previouſly exhibiting ſeveral cogent reaſons for conſidering pure inflammable air as phlogiſton, or the inflammable principle. Theſe, as being foreign to our preſent object, we paſs over; and haſten to the moſt intereſting part of his third or concluſive Paper.

After examining the effects of the mineral acids upon metallic ſubſtances, and ſlightly conſidering what had been previouſly done by Bergmann, Geoffroy, Morveau, and Wenzel, he lays it down as an axiom, that the quantity of real acid neceſſary to ſaturate a given weight of each baſis, is inverſely as the affinity of each baſis to ſuch acid; and alſo, that the quantity of each baſis requiſite to ſaturate a given quantity of each acid, is directly as the affinity of ſuch acid to each baſis.

He then exhibits a table in which equal quantities of the three ancient mineral acids are ſhewn to take up various quantities of the ſeveral baſes, mineral alkali, calcareous earth, volatile alkali, magneſia, and earth of alum; the quantities of vegetable alkali being equal in all three: becauſe, by his ſuppoſition, the quantities of real acid are taken to be as the quantities of this ſubſtance they are capable of ſaturating. He then goes further, and aſſumes the numerical expreſſion of the quantity of any baſis taken up by an acid, as the expreſſion of its affinity with ſuch baſis; and, on this foundation, he goes on to calculate the effects of double decompoſitions and combinations. In theſe, he diſtinguiſhes the powers which tend to decompoſe by the name of Divellent Affinities; and thoſe which tend to preſerve the original combinations, he calls Quieſcent Affinities. Thus, ſince a decompoſition will always take place when the ſum of the divellent affinities is greater than that of the quieſcent; and, on the contrary, ſince no decompoſition will happen when the ſum of the quieſcent affinities is ſuperior or equal to that of the divellent: all we have to do therefore is to compare the ſums of theſe powers. In this way, by the aſſiſtance of his general principle, he exhibits various inſtances of the application of this doctrine. For example, if vitriolated tartar and the nitrous

ſalt

ſalt of lime be mixed together, a double decompoſition will take place; the lime quitting the nitrous acid, and forming ſelenite with the vitriolic acid; at the ſame time that the vegetable alkali quits this laſt acid, and forms nitre by uniting with the nitrous acid. And, on Mr. Kirwan's principles, this is explained as follows:

One hundred grains of his real vitriolic acid diſſolve two hundred and fifteen grains of vegetable alkali; its attraction to the alkali will therefore be expreſſed by the number 215. Again, one hundred grains of real nitrous acid, likewiſe eſtimated by Mr. Kirwan's original ſuppoſition, will diſſolve 96 grains of calcareous earth to ſaturation: the affinity of nitrous acid to calcareous earth is therefore taken to be 96. Theſe affinities, namely of the vitriolic acid to the alkali, and of the nitrous acid to the earth, tend to preſerve the combinations, and conſequently are the quieſcent affinities; and their ſum amounts to 215, added to 96, that is, 311. On the other hand, the nitrous acid tends to combine with the vegetable alkali with the ſame power as the vitriolic, becauſe Mr. Kirwan has aſſumed that the tendency towards this ſubſtance is alike in all acids, or at leaſt in the three mineral acids; this affinity therefore is expreſſed by 215. But the other divellent affinity, namely that of vitriolic acid to calcareous earth, being expreſſed by the quantity of that ſubſtance which one hundred grains of the real vitriolic acid takes up to ſaturation, will be denoted by 110. The divellent affinities conſequently amount to 215 added to 110; that is, 325. And becauſe this divellent power, 325, is greater than the quieſcent power 311, a decompoſition will take place.

After explaining and elucidating the effects of ſolubility, and the ſpecific heats of ſubſtances, on the action of chemical affinity, this author proceeds to exhibit the attractive powers of the three mineral acids to metallic ſubſtances in his way; that is, by aſcertaining how much of each is taken up by a hundred grains of his real acid. I do not give theſe numbers, though they exhibit valuable facts; becauſe much remains yet to be done before Mr. Kirwan's deductions reſpecting the quantities of real acid, and the meaſures of affinity, can be admitted as eſtabliſhed parts of chemical theory.

In the firſt place, as Mr. Kirwan himſelf obſerves, there can be no deduction made of the quantities of real acid from the quantities of vegetable alkali which acids of various kinds ſaturate, if it ſhould appear that the attractions of theſe acids towards that ſubſtance ſhould differ as well as their quantities. And this ſuppoſition, that they do not differ, is not only gratuitous, but inconſiſtent with the general tenour of chemical facts; among which it would be difficult, and perhaps impoſſible, to exhibit by experiment three ſubſtances poſſeſſing preciſely or nearly the ſame attraction to a fourth ſubſtance. It may be eaſily imagined what confuſion, or variation of reſult, would have ariſen through the whole of Mr. Kirwan's inferences, if he had aſſumed the mineral alkali inſtead of the vegetable, as the foundation of his admeaſurement; and ſtill more, if calcareous earth or magneſia had been thus aſſumed: none of which ſubſtances, for any thing which has been alleged to the contrary, are entitled either to reception or excluſion in founding this ſyſtem. It may alſo be obſerved, that the original meaſure of the real acids being founded upon the ſuppoſition, that marine acid air contains no water; and as this ſuppoſition can by no means be admitted ſince the later experiments of Dr. Prieſtley, from which it is rendered highly probable, that water compoſes a large proportion of every aëriform ſubſtance; the real marine acid of Mr. Kirwan is no more a pure and determinate ſubſtance than any other marine acid of a known temperature and ſpecific gravity.

It might perhaps be rendered probable, from the ſucceſsful application of Mr. Kir-

wan's numbers to the facts of compound affinities, that the principle of the quantities diſſolved might prove much more uſeful than Wenzel's principle of the times of the ſolutions, if it were not that all the deductions are vitiated by the admiſſion of quantities of ſuppoſed real acid, the uncertainty of which prevents our diſcerning how far the principle is or is not applicable. It may be obſerved, however, that the value of this principle, whatever it may prove, muſt be aſcertained by experiment only, and not at all by reaſoning, which cannot be applied in this caſe: for the fundamental aſſertion, that the attraction of an acid to its baſis is proportionate to the quantity it demands for ſaturation, is ſo far from being founded upon any argument, that it is evidently nugatory. The attraction of an acid to its baſis cannot but be the ſame as that of the baſis to the acid; becauſe action and re-action are equal. We might therefore affirm that the attraction of magneſia to vitriolic acid is greater than that of calcareous earth to the ſame acid, becauſe it requires one-fourth more of that acid for its ſaturation; upon the ſame foundation as Mr. Kirwan aſſerts the contrary, becauſe a given quantity of vitriolic acid takes up more calcareous earth than it does of magneſia. And there are not wanting a ſufficient number of inſtances of acids, weak in attractive power, which require much alkali for their ſaturation, or, in other words, which are taken up by alkalis in ſmall quantities only.

I have not the leaſt doubt but that Mr. Kirwan himſelf has long ſince perceived theſe objections to the theory he brought forward ſo long ago; and it might perhaps have appeared unneceſſary to enter into any diſcuſſion of an attempt which, though not ſucceſsful throughout, has procured him all the honour which his aſſiduity of reſearch, and powers of inveſtigation, are juſtly entitled to, if it did not ſeem highly probable that the numerical expreſſions of the powers of chemical attraction, whenever they ſhall be obtained, will be derived from ſome method dependant on the general facts he then undertook to explain. The time required to effect any change of combination, the correſpondent change of temperature, of ſpecific gravity, of conſiſtency, fluidity, or elaſticity, and the relative quantities of principles required to produce the moſt perfect ſaturation, or to produce a compound the moſt remote in its properties from thoſe of the principles themſelves, are among the objects which require the ſteady attention of thoſe comprehenſive minds which are capable of deducing remote analogies, and tracing the general laws of Nature. Mr. Kirwan is among the firſt who, by duly attending to theſe, has placed them in their true point of importance; and whoever may deduce their mutual relations in future, they will have occaſion to acknowledge their obligation to his inſtructive works.

Thus far we have conſidered the means of inveſtigating and explaining the chemical affinities or attractions; in which two leading things are required to be done, namely, the making of judicious and well-directed experiments, and the deduction of proper inferences from them. Moſt of the errors of chemiſts, and indeed of the cultivators of any ſcience, ariſe from the ſubject being viewed in too confined a light; ſo that ſome eſſential object is overlooked. Nothing can be clearer than that the more ſimple the deſcription or enunciation of theſe objects, the leſs the mind will be burthened, and the leſs probable it will be that any thing of importance will be overlooked. Hence the advantage of a conciſe, ſimple, and accurate ſtyle, which may direct the mind ſteadily to the ſubject in contemplation, without miſleading by ambiguous terms, or the language of the vulgar, which is applicable to ſo many and ſuch various ideas. The advantages of this are ſtrongly felt in the mathematical ſciences, where by diagrams exhibited to the eye, by terms conſtantly

appropriated to the expreſſion of the ſame ideas, or by ſymbols whoſe quantity, value, and application vary with their relative poſitions, the mind is occupied with no other objects than ſuch as tend to forward the deſired inveſtigation. This has in ſome degree been effected in chemical ſcience by Geoffroy, in his firſt table of Simple Elective Attractions; by Bergmann, in his Symbolical Expreſſion of the Effects of Compound Attractions; and by others, in their tables of the Component Parts of Bodies. A deſcription of the tables contained in the enſuing pages, will ſufficiently explain their nature and application.

Tables I. to VI. contain in ſubſtance the two tables of *Attractiones Electivæ Simplices*, placed at the end of Bergmann's Treatiſe upon Elective Attractions, of which a ſeparate tranſlation was publiſhed in London, in the year 1785. I have not made any alteration, except ſuch as has tended to facilitate the inſertion of them in their regular pages of the book, inſtead of adopting the much leſs convenient method of printing upon a large ſheet, to be occaſionally folded out. It will be ſeen therefore that I have avoided repetitions, and altered the arrangement of the columns; but have in no material reſpect changed the ſubſtance of the table itſelf, excepting that the perlate acid, vital air, the matter of heat, and ſiderite, are left out. The perlate acid is now well known to conſiſt of phoſphoric acid united to a certain quantity of mineral alkali; and the ſemi-metal ſiderite is known to conſiſt of the ſame acid united to iron. Vital air, in the tables of Bergmann, is ſuppoſed to have an affinity to phlogiſton only; and the matter of heat, which occupied a column, containing eight ſubſtances, arranged conjecturally, is left out, becauſe of the doubt whether heat be a ſeparate matter, or a mere modification; and alſo becauſe the table of comparative heats or capacities may perhaps indicate the affinities of this ſubſtance, if it be a ſubſtance, better than any other table. (*See* HEAT.) The ſame reaſons which induced me to retain the tables as Bergmann left them, when I publiſhed my Firſt Principles of Chemiſtry, namely, that they might continue to be Bergmann's tables—and that the compilation of new tables of affinity would require a ſeparate correſpondent treatiſe, to aſcertain the degree of dependance to which each column might be entitled—ſtill retain their efficacy; and they are even rendered more cogent, from my obſerving that Mr. Morveau has thought proper to do the ſame in the Encyclopédie Méthodique.

Theſe tables require no other explanation, than that the ſubſtances enumerated are conſidered to be ſimple, as far as relates to the facts exhibited in theſe ſketches. The order of poſition denotes that the higher any ſubſtance ſtands in any column, the ſtronger is its elective attraction to the ſubſtance at the head of that column. The under part of each table exhibits the attractions in the dry way, and muſt be conſidered as entirely diſtinct from the upper part. The horizontal lines between the ſubſtances denote that their poſitions, or comparative powers of attraction, are well determined; and, whenever theſe lines are wanting, the poſitions are more or leſs conjectural.

TABLE

TABLE I. Simple Elective Attractions.

ACIDS.

In the Humid Way.

Vitriolic Acid.	Nitrous Acid.	Marine Acid.	Fixed Air.	Acid of Borax.	Acid of Amber.	Acetous Acid distilled.
Barytes	Vegetable alkali?	Vegetable alkali?	Barytes	Lime	Barytes	Barytes
Vegetable alkali	Mineral alkali?	Mineral alkali?	Lime	Barytes	Lime	Vegetable alkali
Mineral alkali	Barytes?	Barytes?	Vegetable alkali	Magnesia	Magnesia	Mineral alkali
Lime	Lime	Lime	Mineral alkali	Vegetable alkali	Vegetable alkali	Volatile alkali
Magnesia	Magnesia	Magnesia	Magnesia	Mineral alkali	Mineral alkali	Lime
Volatile alkali	Volatile alkali	Volatile alkali	Volatile alkali	Volatile alkali	Volatile alkali	Magnesia
Clay	Clay	Clay	Clay	Clay	Clay	Clay
Metallic calces	Metallic calces	Metallic calces	Metallic calces	Metallic calces	Metallic calces	Metallic calces
Water	Water	Water	Water	Water	Water	Water
Ardent Spirit	Ardent spirit	Ardent Spirit	Ardent Spirit	Ardent spirit	Ardent spirit	Ardent spirit
Phlogiston	Phlogiston	Phlogiston		Phlogiston	Phlogiston	Phlogiston.
N. B. The sulphureous or volatile vitriolic acid follows the same order in the humid way.	N. B. The fuming nitrous acid follows the same order in the humid way.	N. B. The dephlogisticated or aërated marine acid follows the same order in the humid way.		N. B. The same order is followed by the acids of sugar or sorrel; tartar; and lemon.	The order in which the metallic calces precipitate each other in acids, is the reverse of that in the column of phlogiston, in Table IX.	

In the Dry Way.

			Prussian Acid			
Phlogiston	Phlogiston	Phlogiston	In the Humid Way	Lime	Barytes	Barytes
Vegetable alkali	Barytes	Barytes	Vegetable alkali	Barytes	Lime	Vegetable alkali
Mineral alkali	Vegetable alkali	Vegetable alkali	Mineral alkali	Magnesia	Magnesia	Mineral alkali
Barytes	Mineral alkali	Mineral alkali	Volatile alkali	Vegetable alkali	Vegetable alkali	Lime
Lime	Lime	Lime	Lime	Mineral alkali	Mineral alkali	Magnesia
Magnesia	Magnesia	Magnesia	Barytes	Metallic calces	Metallic calces	Metallic calces
Metallic calces	Metallic calces	Metallic calces	Magnesia	Volatile alkali	Volatile alkali	Volatile alkali
Volatile alkali	Volatile alkali	Volatile alkali	Clay	Clay	Clay	Clay
Clay	Clay	Clay	Metallic calces	N. B. The same order both in the humid and dry way is followed by the acids of spar; of arsenic; of benzoin; of sugar of milk; of fat; and of phosphorus; except that phlogiston occupies the first place in the dry way with the arsenical acid.		N. B. The same order both in the humid and dry way is followed by the acids of milk and of ants.
		N. B. Aqua regia follows the same order both in the humid and dry way.	Water			

TABLE II. Simple Elective Attractions.

ALKALIS AND EARTHS.

IN THE HUMID WAY.

VEG. ALKALI.	MIN. ALKALI.	CLAY.	LIME.	BARYTES.	MAGNESIA.
Vitriolic acid		Vitriolic acid	Acid of ſug a. r	Vitriolic acid	Acid of ſugar
Nitrous acid	This alkali agrees with the vegetable in the order of its attractions, both in the humid and the dry way.	Nitrous acid	Vitriolic acid	Acid of ſugar	Phoſphor. acid
Marine acid		Marine acid	Acid of tartar	Acid of amber	Vitriolic acid
Acid of fat		Acid of ſugar	Acid of amber	Acid of ſpar	Acid of ſpar
Acid of ſpar		Arſenical acid	Phoſphoric acid	Phoſphor. acid	Acid of fat
Phoſphor. acid		Sparry acid	A. of ſ. of milk	A. of ſ. of milk	Acid of arſenic
A. of ſugar		Acid of fat	Nitrous acid	Nitrous acid	A. of ſ. of milk
A. of tartar		Acid of tartar	Marine acid	Marine acid	Acid of amber
A. of arſenic		A. of amber	Acid of fat	Acid of fat	Nitrous acid
A. of amber		A. of ſ. of milk	Acid of ſpar	Acid of lemon	Marine acid
A. of lemon		Acid of lemon	Acid of arſenic	Acid of tartar	Acid of tartar
A. of ants	VOL. ALKALI.	Phoſphoric acid	Acid of ants	Acid of arſenic	Acid of lemon
A. of milk		Acid of ants	Acid of milk	Acid of ants	Acid of ants
A. of benzoin	This alkali agrees with the vegetable in the order of its attractions, both in the humid and dry way: but mere heat expels it from the acids of phoſphorus, borax, and arſenic.	Acid of milk	Acid of lemons	Acid of milk	Acid of milk
Acetous acid		Acid of benzoin	A. of benzoin	A. of benzoin	Acid of benzoin
A. of ſ. of milk		Acetous acid	Acetous acid	Acetous acid	Acetous acid
Acid of borax		Acid of borax	Acid of borax	Acid of borax	Acid of borax
Vol. vitr. acid		Vol. vitr. acid	Vol. vitr. acid	Vol. vitr. acid	Vol. vitr. acid
Fuming nitr. a.		Fuming nitr. a.	Fuming nitr. a.	Fuming nitr. a.	Fuming nitr. a.
Fixed air		Fixed air	Fixed air	Fixed air	Fixed air
Pruſſian acid		Pruſſian acid	Pruſſian acid	Pruſſian acid	Pruſſian acid
Water			Water	Water	
Fat oils			Fat oils	Fat Oils	
Sulphur			Sulphur	Sulphur	Sulphur
Metallic calces					

IN THE DRY WAY.

Phoſphor. acid	SILEX.	Phoſphor. acid	Phoſphor. acid	Phoſphor. acid	Phoſphor. acid
Acid of borax		A. of borax	A. of borax	A. of borax	A. of borax
Acid of arſenic	In the HUMID WAY.	A. of arſenic	A. of arſenic	A. of arſenic	A. of arſenic
Vitriolic acid		Vitriolic acid	Vitriolic acid	Vitriolic acid	Vitriolic acid
Nitrous acid	A. of ſpar	Nitrous acid	A. of amber	A. of amber	A. of ſpar
Marine acid	Vegetable alkali	Marine acid	Nitrous acid	A. of ſpar	A. of fat
Acid of fat		A. of ſpar	Marine acid	Nitrous acid	A. of amber
Acid of ſpar		A. of fat	A. of fat	Marine acid	Nitrous acid
Acid of amber	In the DRY WAY	A. of amber	A. of ſpar	A. of fat	Marine acid
Acid of ants		A. of ants	A. of ants	A. of ants	A. of ants
Acid of milk	Fixed alkali	A. of milk	A. of milk	A. of milk	A. of milk
Acid of benzoin	Phoſphor. acid	A. of benzoin	A. of benzoin	A. of benzoin	A. of benzoin
Acetous acid	Calx of lead	Acetous acid	Acetous acid	Acetous acid	Acetous acid
Barytes		Fixed alkali	Fixed alkali	Fixed alkali	Fixed alkali
Lime		Sulphur	Sulphur	Sulphur	Sulphur
Magneſia		Calx of lead	Calx of lead	Calx of lead	Calx of lead
Clay					
Silex					
Sulphur					

TABLE III.

Simple Elective Attractions.

COMBUSTIBLE SUBSTANCES AND WATER.

IN THE HUMID WAY.

WATER.	SULPHUR.	SALINE LIVER OF SULPHUR.	ARDENT SPIRIT.	ETHER.
Vegetable alkali	Calx of lead	Calx of gold	Water	Ardent ſpirit
Mineral alkali	C. of tin	C. of ſilver	Ether	Eſſential oils
Volatile alkali	C. of ſilver	C. of mercury	Eſſential oils	Expreſſed oils
Ardent ſpirit	C. of mercury	C. of arſenic	Volatile alkali	Water
Mild volatile alk.	C. of arſenic	C. of antimony	Fixed alkali	Sulphur
Glauber's ſalt	C. of antimony	C. of biſmuth	Saline hepar	
Ether	C. of iron	C. of copper	Sulphur	
	Vegetable alkali	C. of tin		
	Volatile alkali	C. of lead		
	Barytes	C. of nickel	EXPRESSED OIL.	ESSENTIAL OIL.
	Lime	C. of cobalt		
	Magneſia	C. of manganeſe		
Vitriolic acid		C. of iron	Ether	Ether
Vitriolated tartar	Fat Oils		Eſſential oils	Ardent ſpirit
Alum	Eſſential Oils	Ardent ſpirit	Fixed alkalis	Fat oils
Martial vitriol	Ether	Water	Vol. alkali	Fixed alkalis
Corroſive ſublimate	Ardent ſpirit		Sulphur	Sulphur

IN THE DRY WAY.

Fixed alkalis	Manganeſe
Iron	Iron
Copper	Copper
Tin	Tin
Lead	Lead
Silver	Silver
Cobalt	Gold
Nickel	Antimony
Biſmuth	Cobalt
Antimony	Nickel
Mercury	Biſmuth
Arſenic	Mercury
	Arſenic

TABLE IV. Simple Elective Attractions.

PHLOGISTON AND METALS.

IN THE HUMID WAY.

PHLOGISTON.	CALX OF GOLD.	C. OF SILVER.	C. OF PLATINA.	C. OF MERCURY	C. OF LEAD.
Nitrous acid	Ether	Marine acid	Ether	Acid of fat	Vitriolic acid
Vitriolic acid	Marine acid	Acid of fat	Marine acid	Marine acid	Acid of fat
Dephl. marine a.	Aqua regia	Acid of ſugar	Aqua regia	Acid of ſugar	A. of f. of milk
Arſenical acid	Nitrous acid	Vitriolic acid	Nitrous acid	Acid of amber	A. of ſugar
Phoſphor. acid	Vitriolic acid	A. of f. of milk	Vitriolic acid	Arſenical acid	Arſenical acid
	Arſenical acid	Phoſphor. acid	Arſenical acid	Phoſphoric acid	Acid of tartar
C. platina	Sparry acid	Nitrous acid	Sparry acid	Vitriolic acid	Phoſphor. acid
C. gold	Acid of tartar	Arſenical acid	Acid of tartar	A. of f. of milk	Marine acid
C. ſilver	Phoſphor. acid	Sparry acid	Phoſphor. acid	Acid of tartar	Nitrous acid
C. mercury	Acid of fat	Acid of tartar	Acid of fat	Acid of lemon	Sparry acid
C. arſenic	Pruſſian acid	Acid of lemon	Acid of ſugar	Nitrous acid	Acid of lemons
C. antimony		Acid of ants	Acid of lemons	Sparry acid	Acid of ants
C. biſmuth		Acid of milk	Acid of ants	Acetous acid	Acid of milk
C. copper		Acetous acid	Acid of milk	Acid of borax	Acetous acid
C. tin		Acid of amber	Acetous acid	Pruſſian acid	Acid of borax
C. lead		Pruſſian acid	Acid of amber	Fixed air	Pruſſian acid
C. nickel		Fixed air			Fixed air
C. cobalt	Fixed alkali				Fixed alkali
C. manganeſe	Vol. alkali	Vol. alkali			
C. iron					
C. zinc					
Water					

N. B. In the antiphlogiſtic theory, the column intitled *Phlogiſton* being taken in a reverſed order, will expreſs the elective attractions of *Vital Air*.

IN THE DRY WAY.

	GOLD.	SILVER.	PLATINA.	MERCURY.	LEAD.
C. of platina	Mercury	Lead	Arſenic	Gold	Gold
C. gold	Copper	Copper	Gold	Silver	Silver
Acid of arſenic	Silver	Mercury	Copper	Platina	Copper
C. ſilver	Lead	Biſmuth	Tin	Lead	Mercury
C. mercury	Biſmuth	Tin	Biſmuth	Tin	Biſmuth
C. arſenic	Tin	Gold	Zinc	Zinc	Tin
C. antimony	Antimony	Antimony	Antimony	Biſmuth	Antimony
C. biſmuth	Iron	Iron	Nickel	Copper	Platina
C. copper	Platina	Manganeſe	Cobalt	Antimony	Arſenic
C. tin	Zinc	Zinc	Manganeſe	Arſenic	Zinc
C. lead	Nickel	Arſenic	Iron	Iron	Nickel
C. nickel	Arſenic	Nickel	Lead		Iron
C. cobalt	Cobalt	Platina	Silver		
C. manganeſe	Manganeſe		Mercury		
C. iron	Sa. liv. of ſulph.	S. l. of ſulph.	S. l. of ſulphur	S. l. of ſulph.	S. l. of ſulphur
C. zinc		Sulphur		Sulphur	Sulphur

TABLE V. Simple Elective Attractions.

METALLIC SUBSTANCES.

IN THE HUMID WAY.

Calx of Copper.	Calx of Iron.	Calx of Tin.	Calx of Bismuth.	Calx of Nickel.	Calx of Arsenic.
Acid of ſugar	Acid of ſugar	Acid of fat	Acid of ſugar	Acid of ſugar	Marine acid
Acid of tartar	Acid of tartar	Acid of tartar	Acid of arſenic	Acid of ſorrel	Acid of ſugar
Marine acid	Vitriolic acid	Marine acid	Acid of tartar	Marine acid	Vitriolic acid
Vitriolic acid	A. of ſ. of milk	Vitriolic acid	Phoſphor. acid	Vitriolic acid	Nitrous acid
A. of ſ. of milk	Marine acid	Acid of ſugar	Vitriolic acid	Acid of tartar	Acid of fat
Nitrous acid	Nitrous acid	Arſenical acid	Acid of fat	Nitrous acid	Acid of tartar
Acid of fat	Acid of fat	Phoſphor. acid	Marine acid	Acid of fat	Phoſphor. acid
Arſenical acid	Phoſphor. acid	Nitrous acid	Nitrous acid	Phoſphor. acid	Acid of ſorrel
Phoſphor. acid	Arſenical acid	Acid of amber	Fluor acid	Fluor acid	Fluor acid
Acid of amber	Sparry acid	Sparry acid		A. of ſ. of milk	A. of ſ. of milk
Sparry acid	Acid of amber	A. of ſ. of milk		Acid of amber	Acid of amber
Acid of lemon	Acid of lemons	Acid of lemons		Acid of lemon	Acid of lemon
Acid of ants	Acid of ants	Acid of ants		Acid of ants	Acid of ants
Acid of milk	Acid of milk	Acid of milk		Acid of milk	Acid of milk
Acetous acid	Acetous acid	Acetous acid		Acetous acid	Arſenical acid
Acid of borax	Acid of borax	Acid of borax		Arſenical acid	Acetous acid
Pruſſian acid	Pruſſian acid	Pruſſian acid		Acid of borax	
Fixed air	Fixed air			Pruſſian acid	Pruſſian acid
Fixed alkali		Fixed alkali		Aerial acid	
Vol. alkali		Vol. alkali		Volatile alkali	Volatile alkali
Fat oils					Unctuous oils
					Water

IN THE DRY WAY.

Copper.	Iron.	Tin.	Bismuth.	Nickel.	Arsenic.
Gold	Nickel	Zinc	Lead	Iron	Nickel
Silver	Cobalt	Mercury	Silver	Cobalt	Cobalt
Arſenic	Manganeſe	Copper	Gold	Arſenic	Copper
Iron	Arſenic	Antimony	Mercury	Copper	Iron
Manganeſe	Copper	Gold	Antimony	Gold	Silver
Zinc	Gold	Silver	Tin	Tin	Tin
Antimony	Silver	Lead	Copper	Antimony	Lead
Platina	Tin	Iron	Platina	Platina	Gold
Tin	Antimony	Manganeſe	Nickel	Biſmuth	Platina
Lead	Platina	Nickel	Iron	Lead	Zinc
Nickel	Biſmuth	Arſenic	Zinc	Silver	Antimony
Biſmuth	Lead	Platina		Zinc	
Cobalt	Mercury	Biſmuth			
Mercury		Cobalt			
Sal. liv. of ſulph.	S. l. of ſulphur	S. l. of ſulphur	S. l. of ſulphur	S. l. of ſulphur	S. l. of ſulphur
Sulphur	Sulphur	Sulphur	Sulphur	Sulphur	Sulphur

TABLE VI. Simple Elective Attractions.

METALLIC SUBSTANCES.

IN THE HUMID WAY.

Calx of Cobalt.	Calx of Zinc.	Calx of Antimony.	Calx of Manganese.	Calx of Wolfram.
Acid of ſugar	Acid of ſugar	Acid of fat	Acid of ſugar	Lime
Acid of ſorrel	Vitriolic acid	Marine acid	Acid of ſorrel	Vegetable alkali
Marine acid	Marine acid	Acid of ſugar	Acid of lemon	Volatile alkali
Vitriolic acid	Acid of ſ. of milk	Vitriolic acid	Phoſphoric acid	
Acid of tartar	Nitrous acid	Nitrous acid	Acid of tartar	
Nitrous acid	Acid of fat	Acid of tartar	Fluor acid	
Acid of fat	Acid of ſorrel	Acid of ſorrel	Marine acid	In the Dry Way.
Phoſphoric acid	Acid of tartar	Acid of ſ. of milk	Vitriolic acid	Fixed alkali
Fluor acid	Phoſphoric acid	Phoſphoric acid	Nitrous acid	Lime
Acid of ſ. of milk	Acid of lemon	Acid of lemon	Acid of ſ. of milk	Calx of iron
Acid of amber	Acid of amber	Acid of amber	Acid of amber	Calx of manganeſe
Acid of lemon	Fluor acid	Fluor acid	Acid of fat	
Acid of ants	Arſenical acid	Arſenical acid	Arſenical acid	This column is additional. It is deduced from De Luyart's Analyſis.
Acid of milk	Acid of ants	Acid of ants	Acid of ants	
Acetous acid	Acid of milk	Acid of milk	Acid of milk	
Arſenical acid	Acetous acid	Acetous acid	Acetous acid	
Acid of borax	Acid of borax	Acid of borax		
Pruſſian acid	Pruſſian acid	Pruſſian acid	Pruſſian acid	
Aërial acid	Aerial acid	Aerial acid	Aerial acid	
Volatile alkali	Volatile alkali			

IN THE DRY WAY.

Cobalt.	Zinc.	Antimony.	Manganese.	Wolfram.
Iron	Copper	Iron	Copper	Iron
Nickel	Antimony	Copper	Iron	Silver
Arſenic	Tin	Tin	Gold	Tin
Copper	Mercury	Lead	Silver	Lead
Gold	Silver	Nickel	Tin	Antimony
Platina	Gold	Silver		Biſmuth
Tin	Cobalt	Biſmuth		Manganeſe
Antimony	Arſenic	Zinc		Gold
Zinc	Platina	Gold		Platina
	Biſmuth	Platina		
	Lead	Mercury		
	Nickle	Arſenic		
	Iron	Cobalt		
Saline liv. of ſulph.		Sal. liv. of ſulphur	Sal. liv. of ſulphur	
Sulphur		Sulphur		

In the expreſſion of compound affinities, it is clear, from what has already been ſaid in this article, that theſe ſketches muſt either be made from actual experiment in every inſtance, or by deduction from the numerical expreſſions of the forces of attraction. We have explained ſome of the difficulties which oppoſe the deduction of theſe numbers: but as a conjectural ſet of numbers, inferred from ſuch facts as we poſſeſs, may be uſeful in many inſtances to point out the probability of decompoſitions previous to trial, I have here inſerted Mr. Morveau's table of the numerical expreſſion of affinity between the alkalis and ſoluble earths and the five principal acids.

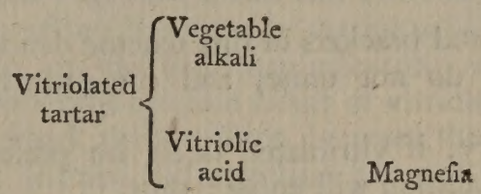
TABLE VII.

Numerical Expreſſion of Affinities by M. MORVEAU.

	Vitriolic Acid.	Nitrous Acid.	Marine Acid.	Acetous Acid.	Aerial Acid, or Fixed Air.
Ponderous earth	65	62	36	29	14
Vegetable alkali	62	58	32	26	9
Mineral alkali	58	50	28	25	8
Lime	54	44	20	19	12
Volatile alkali	46	38	14	20	4
Magneſia	50	40	16	17	6
Argil. earth	40	36	10	15	2

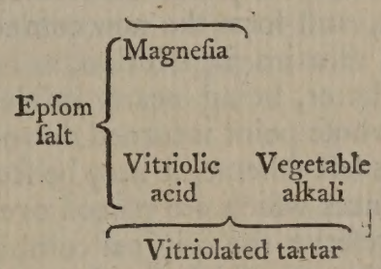
The method of exemplifying or exhibiting ſimple or compound affinities by ſymbols, according to Bergmann, conſiſts in placing thoſe ſubſtances which are applied to each other upon the ſame horizontal line of direction; the component parts of the ſubſtances being placed at the two extremities of a vertical bracket; and the new products, if any, are placed one above the other, at the middle part of an horizontal bracket, connecting their component principles. This will be rendered clearer by an example.

I. Suppoſe magneſia to be preſented to a ſolution of vitriolated tartar, it will be found that no decompoſition takes place. Theſe facts are expreſſed as follows:



In the above ſcheme, the vitriolated tartar is placed oppoſite the point of a vertical bracket, and its two component parts, vegetable alkali and vitriolic acid, are placed within the extremities of the ſame bracket. Horizontally oppoſite the vitriolic acid is placed magneſia, to denote that it is preſented to that acid. And as theſe two ſubſtances are not connected by a bracket, it is to be underſtood from the ſcheme that they do not unite, and conſequently that the vitriolated tartar remains undecompoſed.

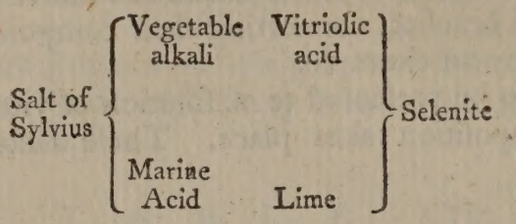
II. On the contrary, if to a ſolution of Epſom ſalt the vegetable alkali be added, a decompoſition will enſue, which is expreſſed as follows:



The arrangements in this ſcheme depend on the ſame principles as thoſe of the foregoing: but the bracket underneath the vitriolic acid, and vegetable alkali, denotes that theſe two ſubſtances unite, and form vitriolated tartar, which is accordingly placed beneath the middle of the bracket. The point of the bracket being turned up, is made to denote that the compound remains ſuſpended, or in ſolution. The magneſia is of courſe diſengaged; and half a bracket, with the point downwards, is placed over it, to denote that it falls to the bottom, or is precipitated.

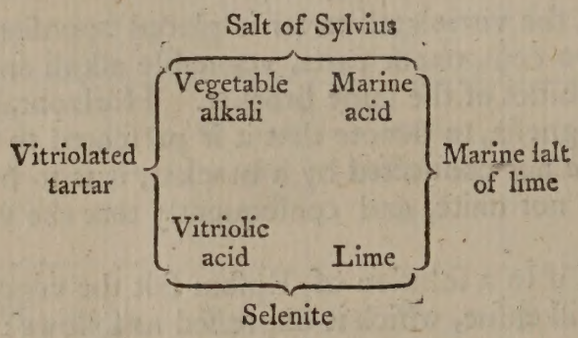
III The

III. The above inſtances exhibit ſimple elective attractions; but this method is more particularly applicable to the compound attractions; for example, ſuppoſe a ſolution of the ſalt of Sylvius be added to ſelenite, no decompoſition will take place. This is expreſſed as under:



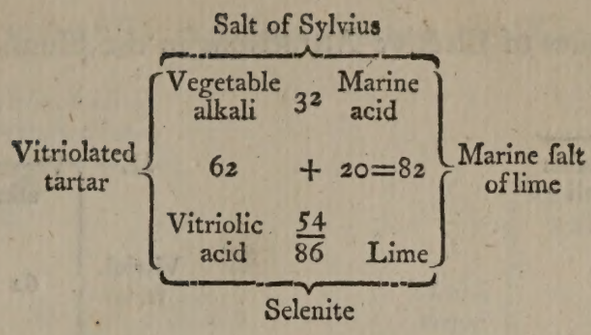
The want of horizontal brackets in this ſcheme denotes that the principles preſented to each other do not unite, and conſequently that no decompoſition enſues.

IV. On the contrary, if vitriolated tartar be preſented to the marine ſalt of lime, a mutual decompoſition will enſue; thus,



In this ſcheme, we ſee that the principles preſented to each other do unite, as is ſhewn by the horizontal brackets, and form the new compounds, ſalt of Sylvius and ſelenite; the former of which remains in ſolution, as is ſhewn by its bracket being turned upwards; while the latter, being nearly inſoluble, falls down, and is accordingly denoted by a bracket whoſe point is turned downwards.

V. By attentively obſerving this laſt ſcheme, it may be ſeen that the attractions exerted between the ſimple ſubſtances which are placed over each other, are the quieſcent affinities, and tend to preſerve the original combinations; whereas the attractions between the ſimple ſubſtances, which ſtand oppoſite to each other, are the divellent affinities, and tend to produce new combinations. If we were in poſſeſſion of complete tables of the numerical expreſſion of ſimple attraction, it is evident that we might foretel every reſult which might be produced by the application of compound ſubſtances to each other; and we ſhall ſee the utility of Mr. Morveau's Table, by applying the numbers to the preceding ſcheme.



The attraction between the vegetable alkali and vitriolic acid is expreſſed by the number 62; and the attraction between the marine acid and lime is expreſſed by the number 20. Theſe are the quieſcent affinities, and their ſum 82 expreſſes the tendency to preſerve the original forms of vitriolated tartar and marine ſalt of lime. On the other hand, the attraction between the vegetable alkali and marine acid is expreſſed by 32, and the attraction between vitriolic acid and lime by 54. The ſum of 32 and 54 amounts to 86, and expreſſes the divellent affinities which tend to produce new combinations. And as this laſt ſum exceeds the ſum of the quieſcent affinities, it follows that the double decompoſition will take place.

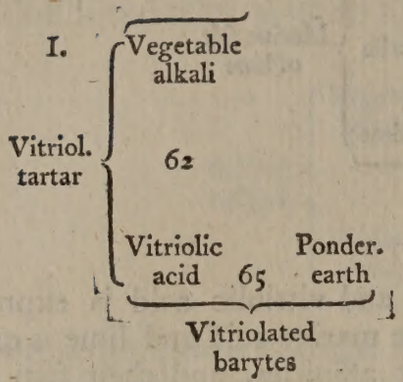
VI. In theſe examples we have deſignedly taken them the reverſe of each other; but every inſtance, ſingly exhibited, does in fact point out both the affirmative and the negative propoſitions. Thus, from the fact firſt exhibited, that magneſia does not decompoſe the combination of vegetable alkali and vitriolic acid, it likewiſe follows that the vegetable alkali does decompoſe the combination of vitriolic acid and magneſia. And accordingly, in the two laſt ſchemes of double affinity, it is clearly aſcertained, from the mutual decompoſition of vitriolated tartar and marine ſalt of lime, that the ſalt of Sylvius and ſelenite will not decompoſe each other.

The ſame horizontal bracket, which in the humid way was uſed to denote ſolution, is uſed to denote ſublimation in experiments by the dry way.

The following ſchemes from Bergmann will require no explanation, after the inſtances we have exhibited.

Schemes of Elective Attractions in the Humid Way.

I.



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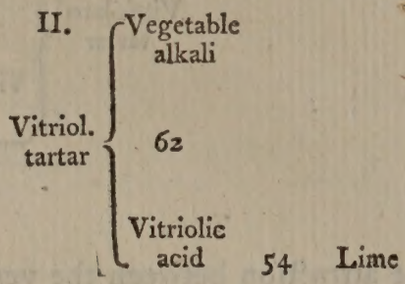

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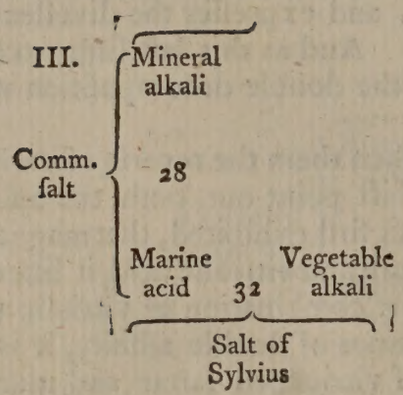

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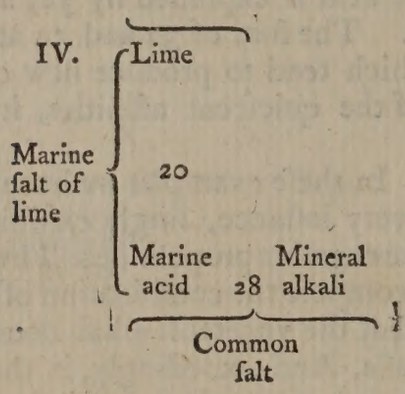

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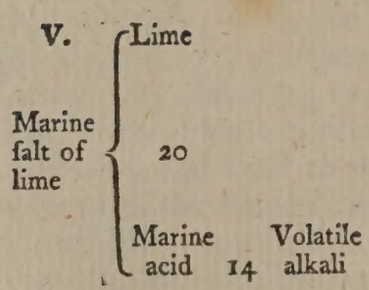

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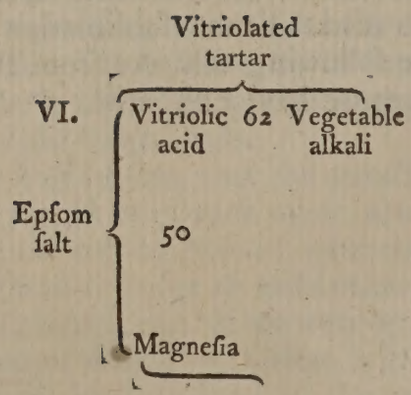

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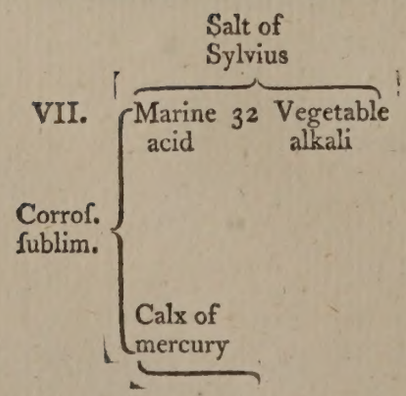

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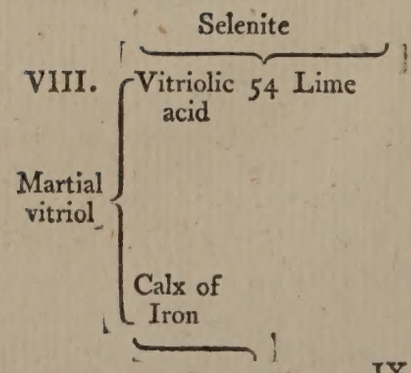
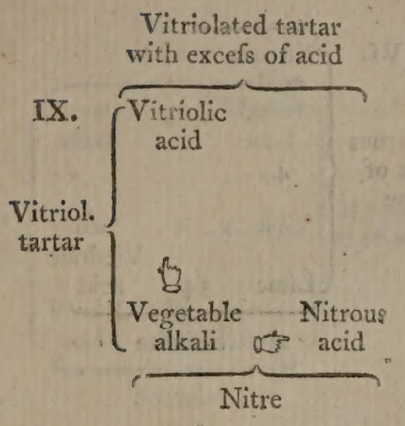
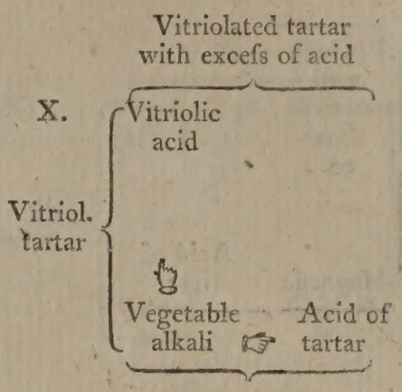
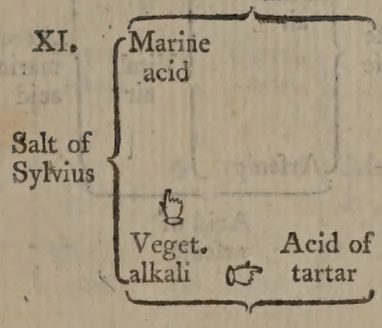


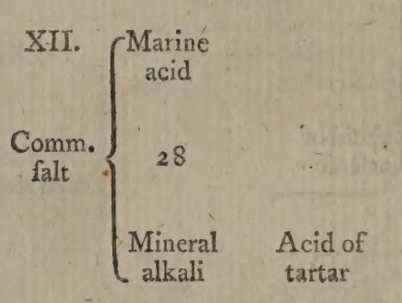
IX. Vitri-

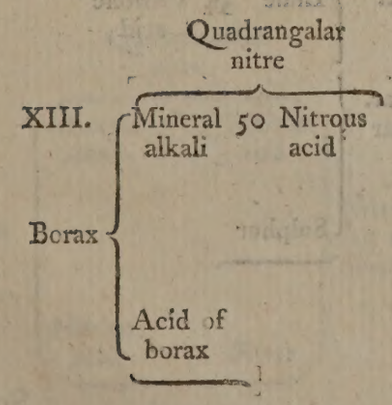
Schemes of Elective Attractions in the Humid Way.

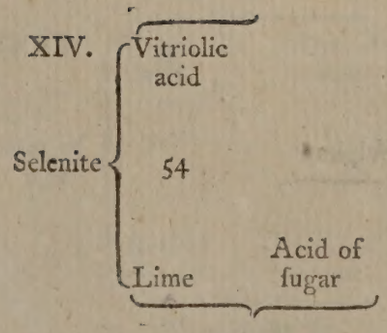






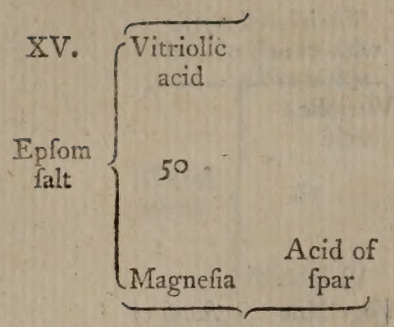






Schemes of Elective Attractions in the Humid Way.

XV.



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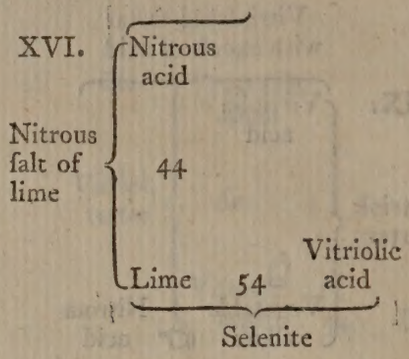

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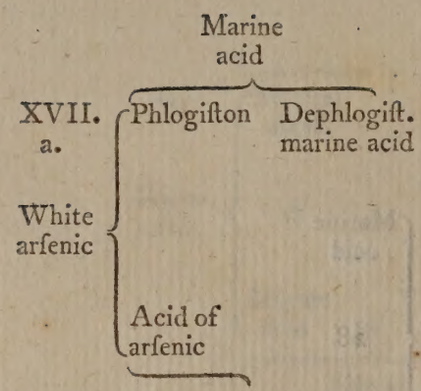

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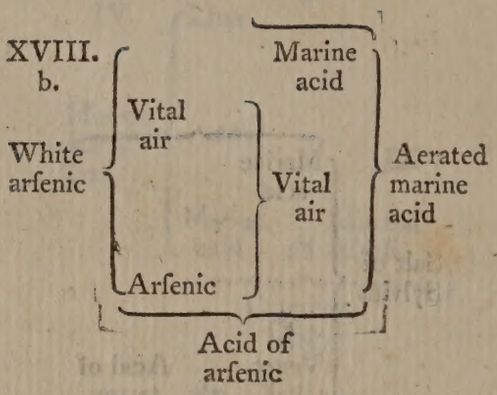

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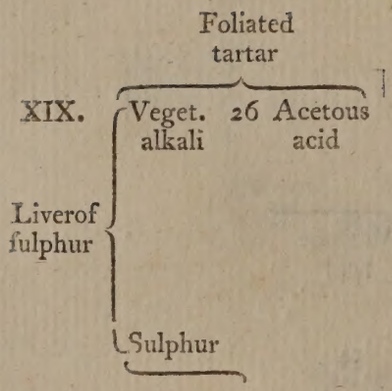

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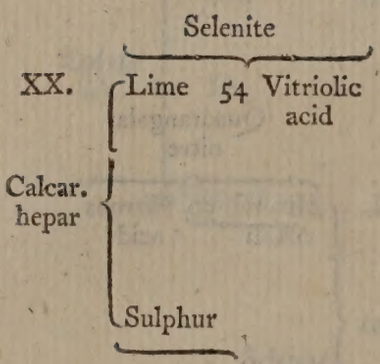

Schemes

Schemes of Elective Attractions in the Humid Way.

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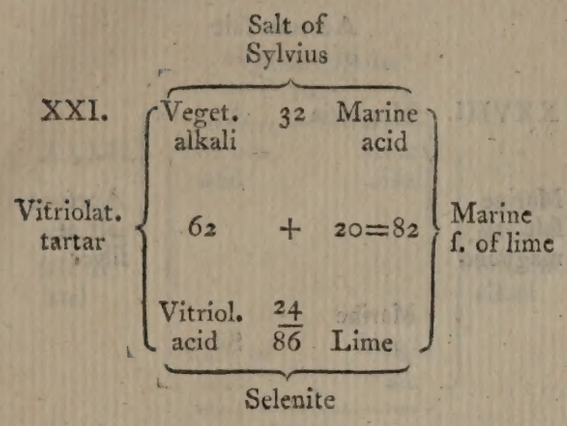

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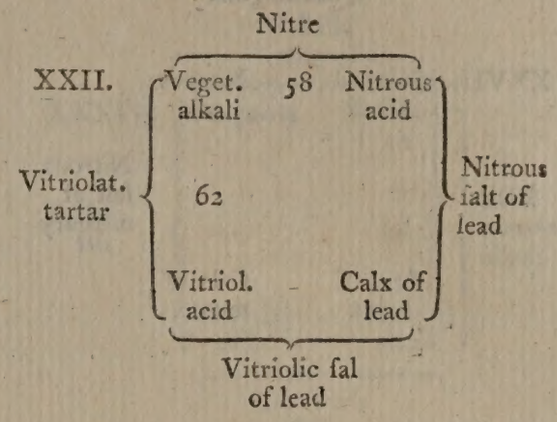

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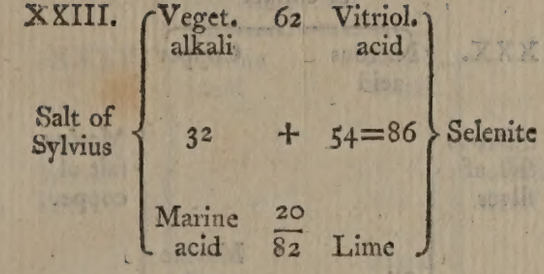

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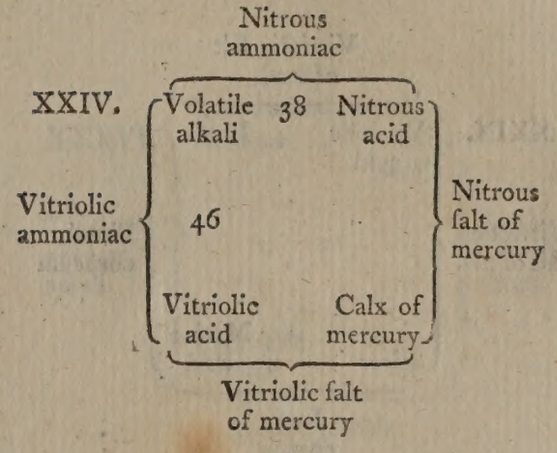

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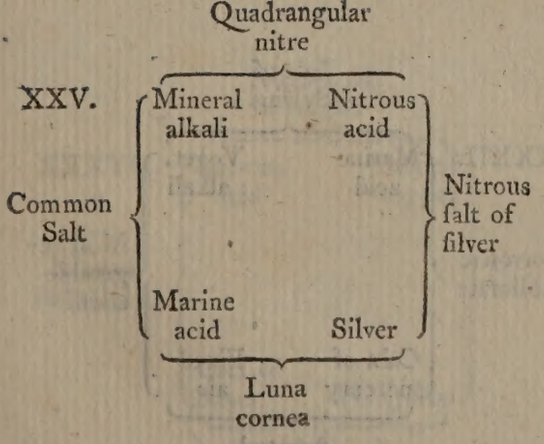

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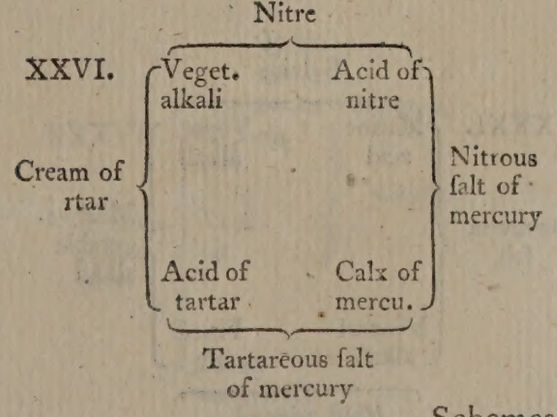
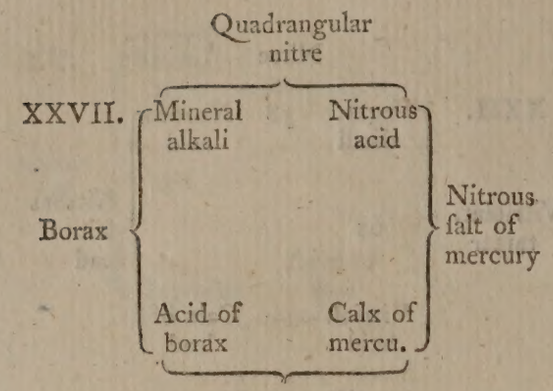


Schemes of Elective Attractions in the Humid Way.

XXVII.



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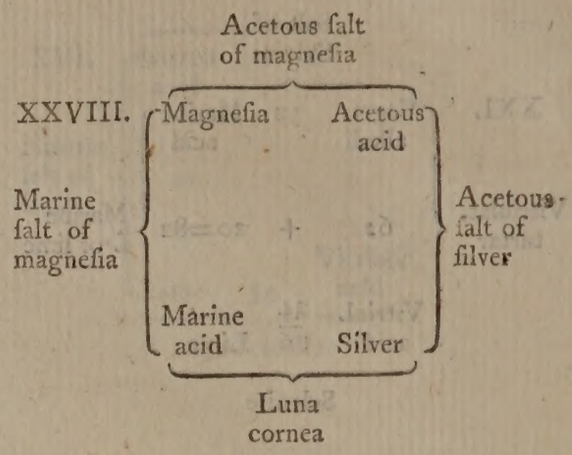

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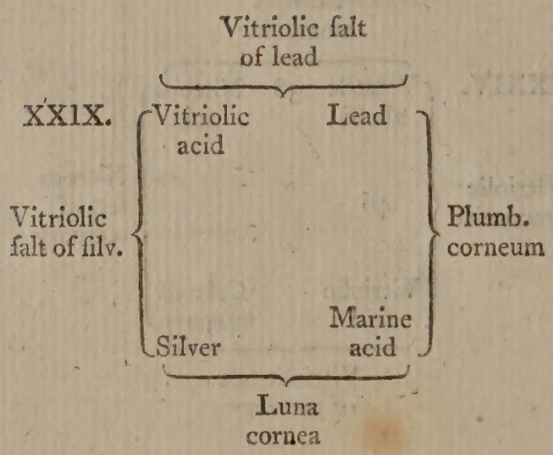

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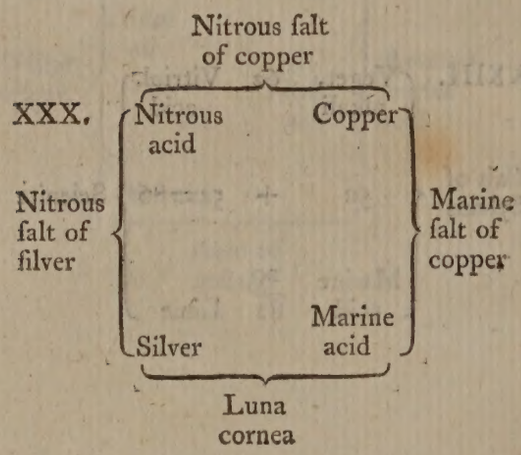

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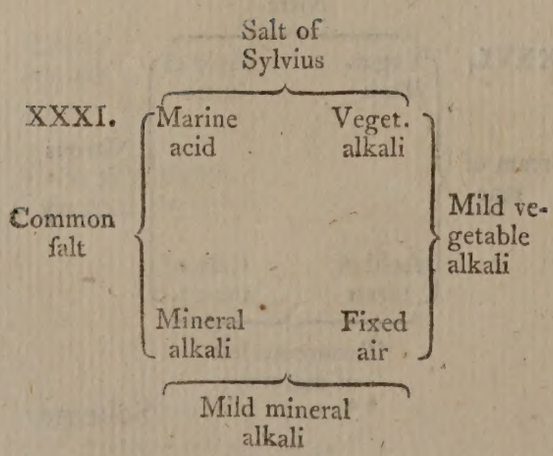

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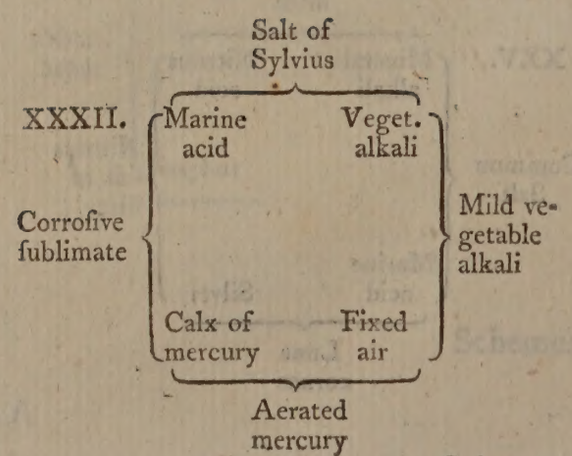
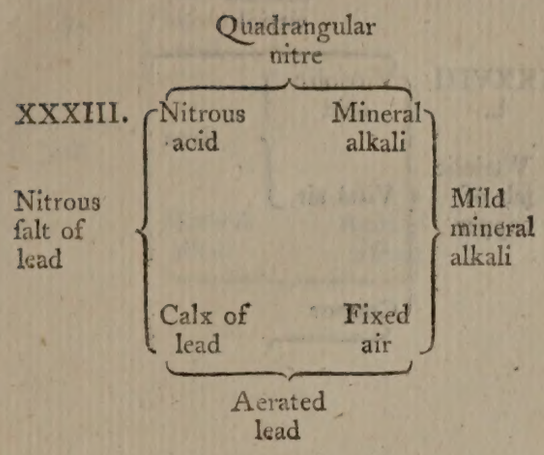
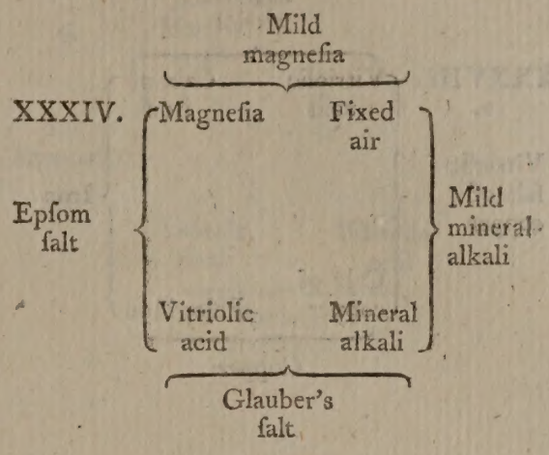
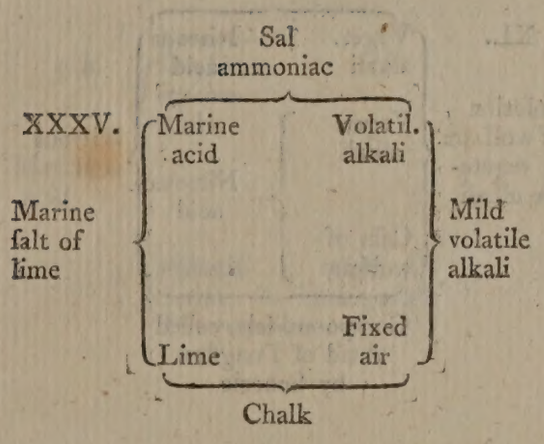


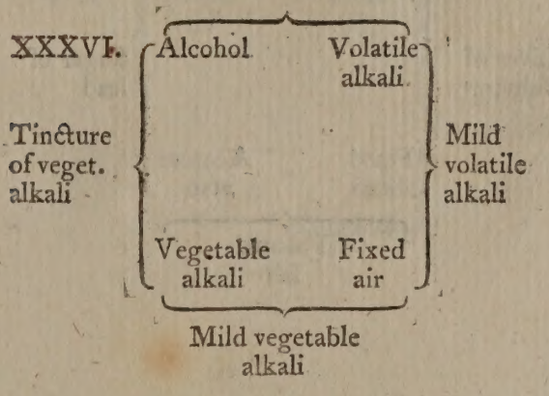
Schemes

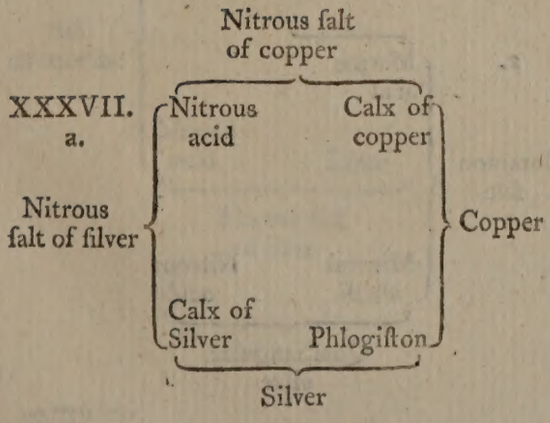
Schemes of Elective Attractions in the Humid Way.

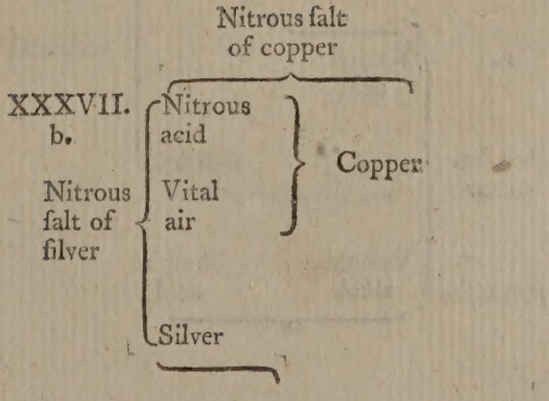






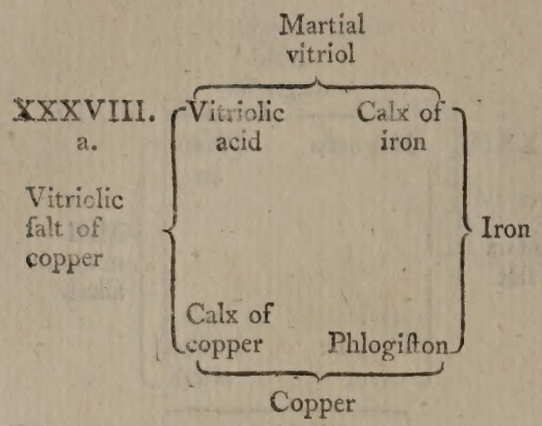


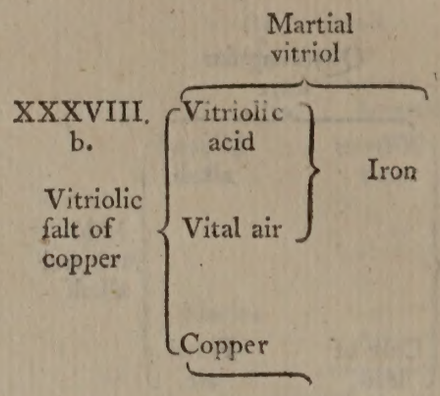


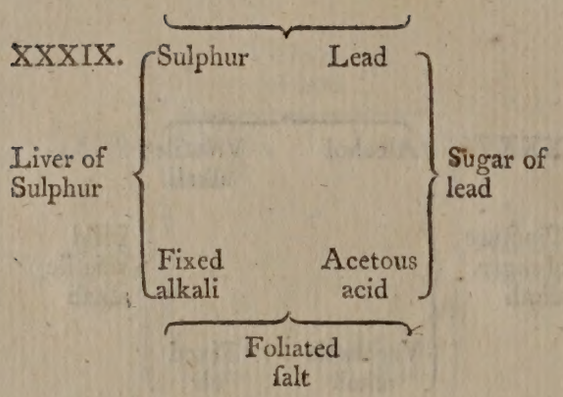


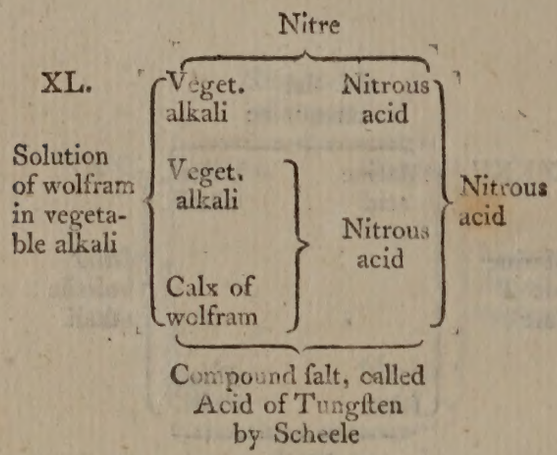
Scheme

Schemes of Elective Attractions in the Humid Way.

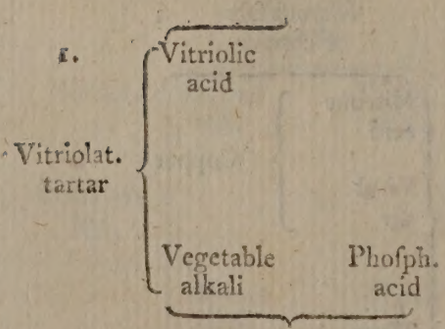


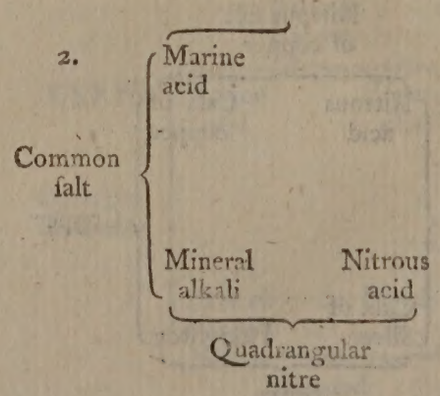






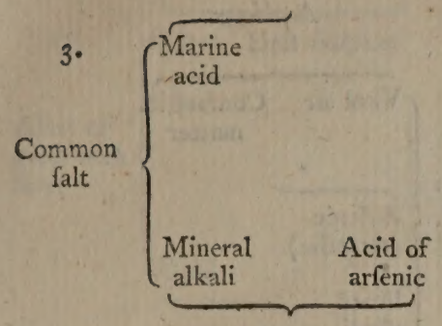
Schemes of Elective Attractions in the Dry Way.

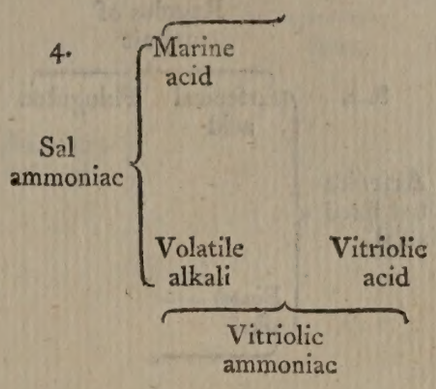


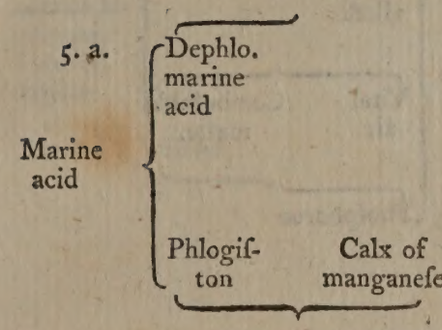


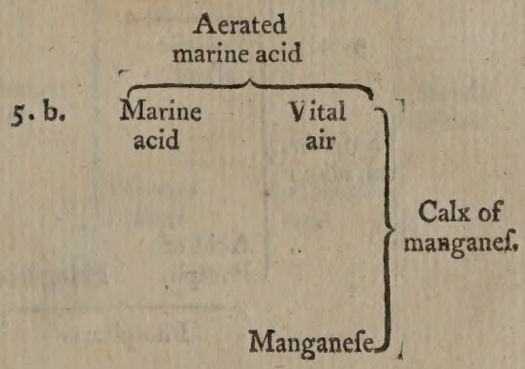
Schemes

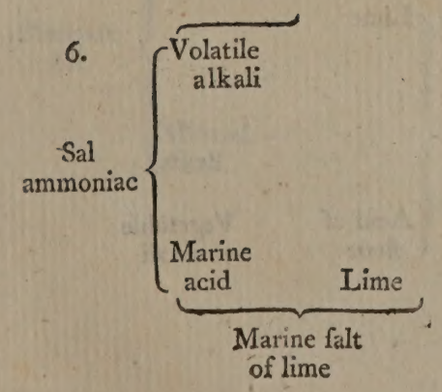
Schemes of Elective Attractions in the Dry Way.

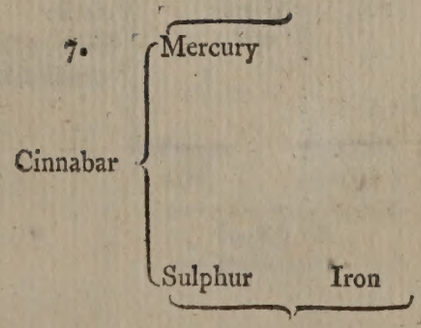






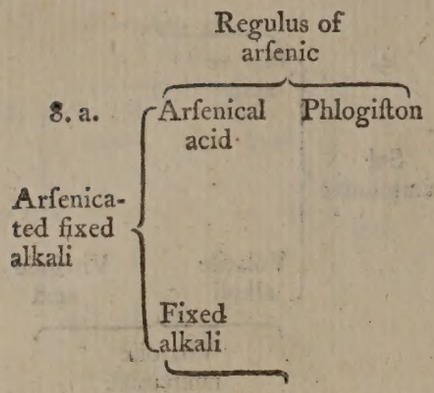


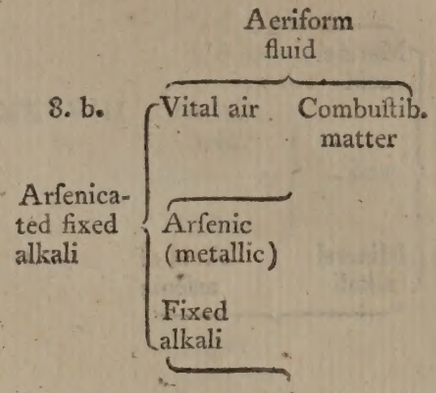


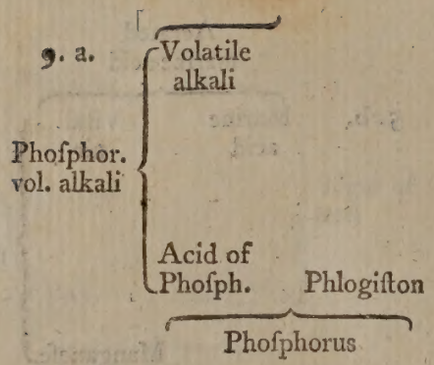


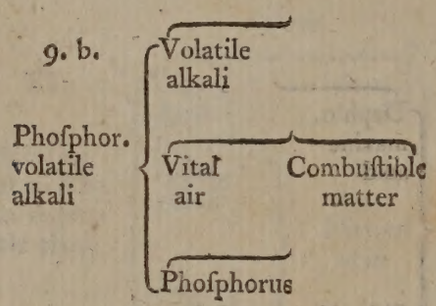
Schemes

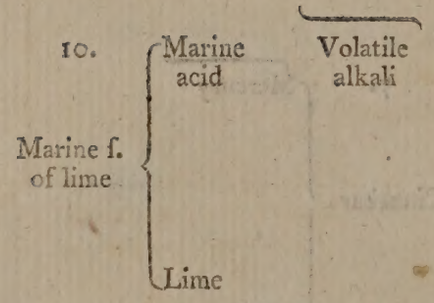
Schemes of Elective Attractions in the Dry Way.

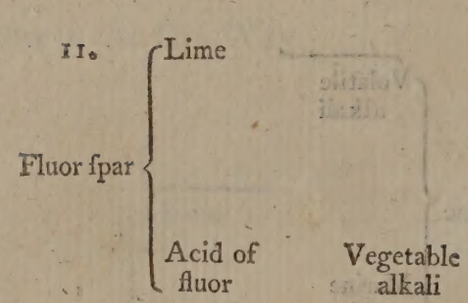




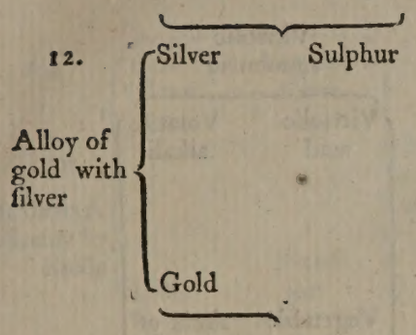


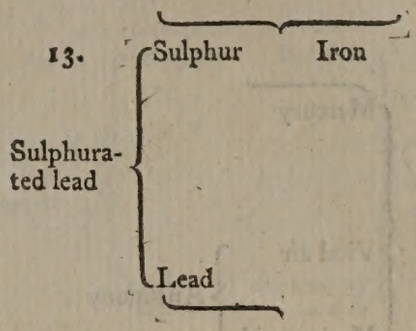


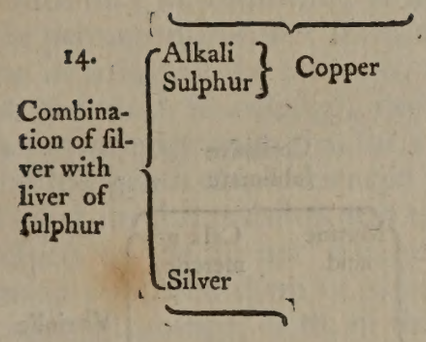


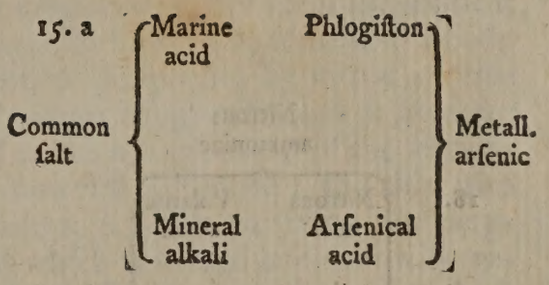


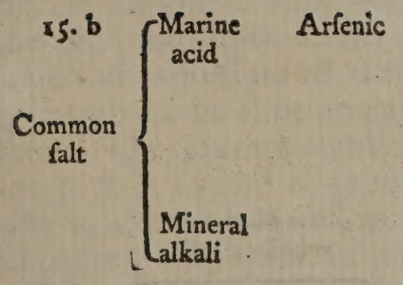
Schemes of Elective Attractions in the Dry Way.

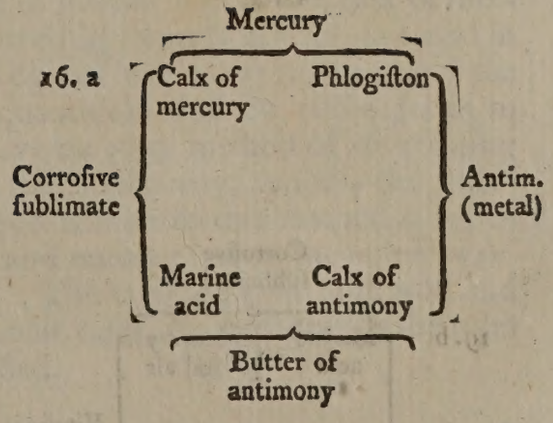






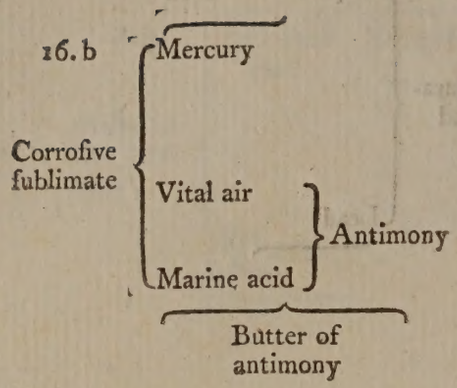






Schemes of Elective Attractions in the Dry Way.

16. b



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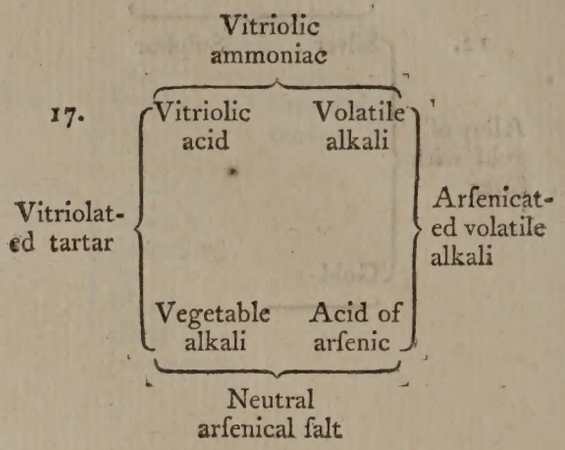

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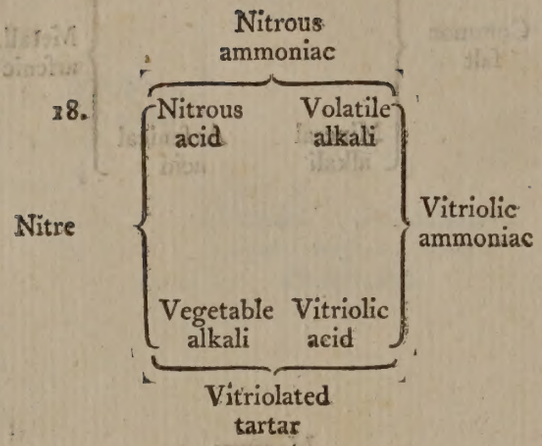

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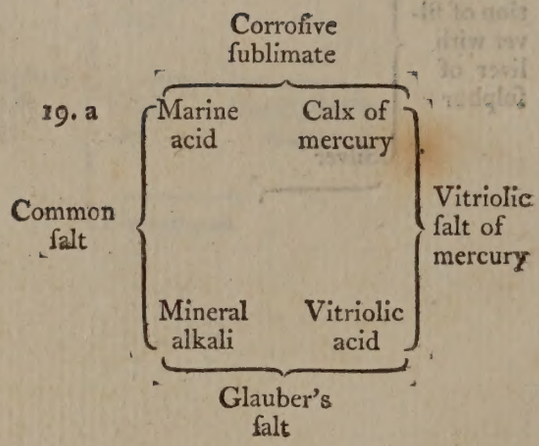

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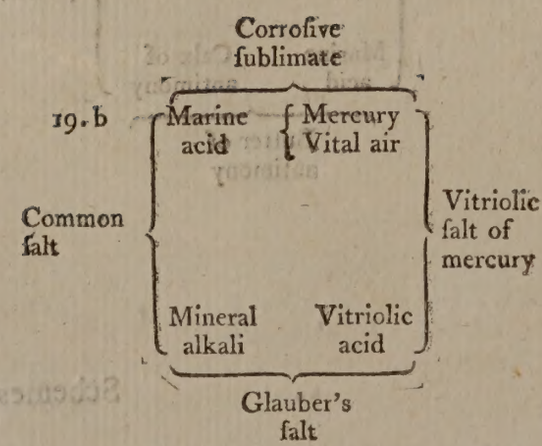

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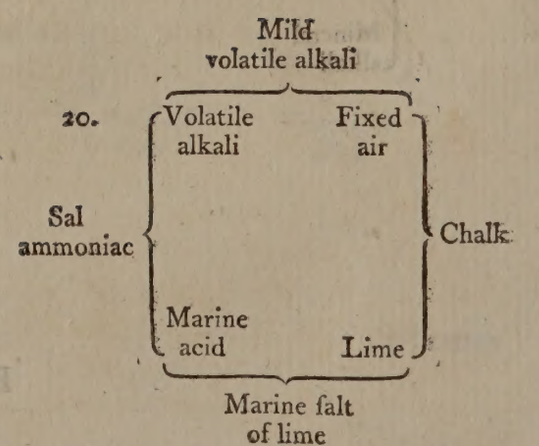
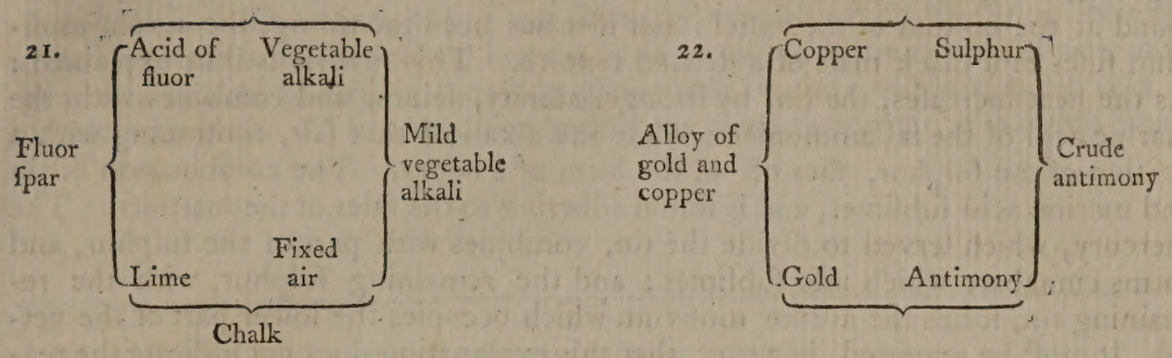


Schemes

Schemes of Elective Attractions in the Dry Way.



I have inſerted the whole of Bergmann's ſchemes, excepting thoſe numbered 25, 55, and 56; the former of which includes the acid of ſorrel, at preſent known to be a compound; and the two laſt relate to experiments with the nitrous acid, which may be conſidered as doubtful, becauſe a large part of the product aſſumes the permanently elaſtic ſtate, and has not been examined. My chief inducement for inſerting all the others is, that the whole together form ſo conſiderable a body of chemical knowledge, expreſſed with ſo much perſpicuity by virtue of this happy arrangement, that their value and effect cannot but greatly tend to promote the reſearches of experienced chemiſts, as well as the advancement of the learner. I ſpeak on this occaſion as if the ſketches were now firſt publiſhed; and this, with reſpect to the greater number of chemical readers, is really the caſe: for Bergmann publiſhed them in characters; a method which is indeed attended with peculiar advantages both in the enunciation and practice of chemiſtry; but which never having been in general uſe, is very far from being familiar even to the learned. The tables have not, that I know of, been before printed in words at length. I have alſo inſerted the numbers of Mr. Morveau, which anſwer as far as they can be applied; and the contemplation of thoſe ſchemes which contain only partial numbers, will ſhew what experiments require to be made to extend them farther. Thus, in ſcheme 7, it is ſeen that the adheſion of marine acid to the calx of mercury, in the humid way, will require a leſs numerical expreſſion than 32; and in ſcheme 8, that the attraction of vitriolic acid to calx of iron is leſs than 54; and the numerical expreſſions of theſe indeterminate quantities muſt be taken ſo as to agree with all the experiments known, as we have no other method of aſcertaining them. The ſchemes numbered 18 and 37 in the humid way, and alſo the numbers 5, 8, 9, 17 and 19 in the dry way, ſhew how admirably this method is applicable to the new, as well as the old theory; and number 40, in the humid way, ſhews the precipitation of a triple compound. The intelligent chemiſt will find no difficulty in extending them to more particular caſes, by attending to the rules of arrangement already deſcribed and exemplified.

AUGITES. *See* AQUA MARINA.

AURUM FULMINANS. *See* GOLD.

AURUM MUSIVUM, *or* MOSAICUM. A combination of tin and ſulphur, which is thus made: Melt twelve ounces of tin, and add to it three ounces of mercury; triturate this amalgam with ſeven ounces of ſulphur, and three of ſal ammoniac. Put the powder into a mattraſs, bedded rather deep in ſand, and keep it for ſeveral hours in a gentle heat; which is afterwards to be raiſed, and conti-

nued for ſeveral hours longer. If the heat has been moderate, and not continued too long, the golden-coloured ſcaly porous maſs, called Aurum Muſivum, will be found at the bottom of the veſſel; but if it has been too ſtrong, the aurum muſivum fuſes to a black maſs of a ſtriated texture. This proceſs is thus explained: As the heat increaſes, the tin, by ſtronger affinity, ſeizes, and combines with, the marine acid of the ſal ammoniac; while the alkali of that ſalt, combining with a portion of the ſulphur, flies off in the form of a hepar. The combination of tin and marine acid ſublimes, and is found adhering to the ſides of the mattraſs. The mercury, which ſerved to divide the tin, combines with part of the ſulphur, and forms cinnabar, which alſo ſublimes; and the remaining ſulphur, with the remaining tin, forms the aurum muſivum which occupies the lower part of the veſſel. It muſt be admitted, however, that this explanation does not indicate the reaſons why ſuch an indirect and complicated proceſs ſhould be required to form a ſimple combination of tin and ſulphur.

It does not appear that the proportions of the materials require to be ſtrictly attended to. The proceſs of the marquis De Bullion, as deſcribed by Chaptal in his Elements of Chemiſtry, conſiſts in amalgamating eight ounces of tin with eight ounces of mercury, and mixing this with ſix ounces of ſulphur, and four of ſal ammoniac. This mixture is to be expoſed for three hours on a ſand heat ſufficient to render the bottom of the mattraſs obſcurely red-hot. But Chaptal himſelf found that if the mattraſs containing the mixture were expoſed to a naked fire, and violently heated, the mixture took fire, and a ſublimate was formed in the neck of the mattraſs, conſiſting of the moſt beautiful aurum muſivum in large hexagonal plates. The marquis De Bullion obtained a good aurum muſivum by diſſolving eight ounces of tin in the muriatic acid, precipitating it by mild mineral alkali, and mixing the precipitate with four ounces of ſulphur. He uſed this mixture inſtead of the foregoing, but found the aurum muſivum unfit to increaſe the effects of the electric machine, as the former aurum muſivum did, which he found to contain ſix parts out of ſeven of mercury, and to which, accordingly, he attributes the effect of electrical excitation.

Aurum muſivum has no taſte, though ſome ſpecimens exhibit an hepatic ſmell. It is not ſoluble in water, acids, or alkaline ſolutions. But in the dry way it forms a yellow hepar, ſoluble in water. It deflagrates with nitre. Bergmann mentions a native aurum muſivum from Siberia, containing tin, ſulphur, and a ſmall proportion of copper.

Aurum muſivum is uſed as a pigment for giving a golden colour to ſmall ſtatues, or plaſter figures. It is likewiſe ſaid to be mixed with melted glaſs to imitate lapis lazuli.

AVIDITY. This term is in common uſe among chemiſts, who apply it to denote that kind of tendency to combination which exerts its effects in a ſhort time. It does not therefore denote the power of attraction, or that by which combinations are moſt ſtrongly maintained; but that modification of the attractive powers which conduces moſt to their ſpeedy exertion. Thus, metallic bodies not being ſoluble in acids but at a certain determinate degree of calcination, and the nitrous acid being more eaſily decompoſed or phlogiſticated than the marine, it is found that the nitrous acid diſſolves moſt metallic ſubſtances with conſiderable rapidity, though the marine does not; but, on the other hand, the attraction of the marine acid to many of the metallic calces is ſuch, that it takes them from the nitrous. The nitrous acid therefore is ſaid to diſſolve the metals with more avidity than

than the marine acid, notwithſtanding the attraction of this laſt appears to be ſtronger.

AZURE. This term, which was formerly applied to the fine blue extracted from lapis lazuli, and at preſent known by the name of Ultramarine, is now more generally applied to denote the blue glaſs made by the combination of calx of cobalt with glaſs. When this is in maſſes, or a coarſe powder, it is called Smalt. *See* COBALT, ULTRAMARINE.

B.

B A L B A L

BALANCE. The beginning and end of every exact chemical proceſs conſiſts in weighing. With imperfect inſtruments this operation will be tedious and inaccurate; but with a good balance, the reſults will be ſatisfactory; and much time, which is ſo precious in experimental reſearches, will be ſaved.

The balance is a lever whoſe axis of motion is formed with an edge like that of a knife; and the two diſhes at its extremities are hung upon edges of the ſame kind. Theſe edges are firſt made ſharp, and then rounded with a fine hone, or a piece of buff leather. The excellence of the inſtrument depends, in a great meaſure, on the regular form of this rounded part. When the lever is conſidered as a mere line, the two outer edges are called Points of Suſpenſion, and the inner the Fulcrum. The points of ſuſpenſion are ſuppoſed to be at equal diſtances from the fulcrum, and to be preſſed with equal weights when loaded.

1. If the fulcrum be placed in the center of gravity of the beam, and the three edges lie all in the ſame right line, the balance will have no tendency to one poſition more than another, but will reſt in any poſition it may be placed in, whether the ſcales be on or off, empty or loaded.

2. If the center of gravity of the beam, when level, be immediately above the fulcrum, it will overſet by the ſmalleſt action; that is, the end which is loweſt will deſcend; and it will do this with more ſwiftneſs, the higher the center of gravity, and the leſs the points of ſuſpenſion are loaded.

3. But if the center of gravity of the beam be immediately below the fulcrum, the beam will not reſt in any poſition but when level; and, if diſturbed from that poſition, and then left at liberty, it will vibrate, and at laſt come to reſt on the level. Its vibrations will be quicker, and its horizontal tendency ſtronger, the lower the center of gravity, and the leſs the weight upon the points of ſuſpenſion.

4. If the fulcrum be below the line joining the points of ſuſpenſion, and theſe be loaded, the beam will overſet, unleſs prevented by the weight of the beam tending to produce an horizontal poſition, as in § 3. In this laſt caſe, ſmall weights will equilibrate, as in § 3; a certain exact weight will reſt in any poſition of the beam, as in § 1; and all greater weights will cauſe the beam to overſet, as in § 2.

Many

Many ſcales are often made this way, and will overſet with any conſiderable load.

5. If the fulcrum be above the line joining the points of ſuſpenſion, the beam will come to the horizontal poſition, unleſs prevented by its own weight, as in § 2. If the center of gravity of the beam be nearly in the fulcrum, all the vibrations of the loaded beam will be made in times nearly equal, unleſs the weights be very ſmall, when they will be ſlower. The vibrations of balances are quicker, and the horizontal tendency ſtronger, the higher the fulcrum.

6. If the arms of a balance be unequal, the weights in equipoiſe will be unequal in the ſame proportion. It is a ſevere check upon a workman to keep the arms equal, while he is making the other adjuſtments in a ſtrong and inflexible beam.

7. The equality of the arms of a balance is of uſe, in ſcientific purſuits, chiefly in making of weights by biſection. A balance with unequal arms will weigh as accurately as another of the ſame workmanſhip with equal arms, provided the ſtandard weight itſelf be firſt counterpoiſed, then taken out of the ſcale, and the thing to be weighed be put into the ſcale, and adjuſted againſt the counterpoiſe; or when proportional quantities only are conſidered, as in chemical and in other philoſophical experiments, the bodies and products under examination may be weighed againſt the weights, taking care always to put the weights into the ſame ſcale. For then, though the bodies may not be really equal to the weights, yet their proportions amongſt each other may be the ſame as if they had been accurately ſo.

8. But though the equality of the arms may be well diſpenſed with, yet it is indiſpenſably neceſſary that their relative lengths, whatever they may be, ſhould continue invariable. For this purpoſe, it is neceſſary, either that the three edges be all truly parallel, or that the points of ſuſpenſion and ſupport ſhould be always in the ſame part of the edge. This laſt requiſite is the moſt eaſily obtained.

The balances made in London are uſually conſtructed in ſuch a manner, that the bearing parts form notches in the other parts of the edges; ſo that the ſcales being ſet to vibrate, all the parts naturally fall into the ſame bearing. The balances made in the country have the fulcrum edge ſtraight, and confined to one conſtant bearing by two ſide plates. But the points of ſuſpenſion are referred to notches in the edges, like the London balances. The balances here mentioned, which come from the country, are incloſed in a ſmall iron japanned box; and are to be met with at the Birmingham and Sheffield warehouſes, though leſs frequently than ſome years ago; becauſe a pocket contrivance for weighing guineas and half-guineas has got poſſeſſion of the market. They are, in general, well-made and adjuſted, turn with the twentieth of a grain when empty, and will ſenſibly ſhew the tenth of a grain, with an ounce in each ſcale. Their price is from five ſhillings to half a guinea; but thoſe which are under ſeven ſhillings have not their edges hardened, and conſequently are not durable. This may be aſcertained by the purchaſer, by paſſing the point of a penknife acroſs the ſmall piece which goes through one of the end boxes; if it makes any mark or impreſſion, the part is ſoft.

9. If a beam be adjuſted ſo as to have no tendency to any one poſition, as in § 1, and the ſcales be equally loaded; then, if a ſmall weight be added in one of the ſcales, that balance will turn, and the points of ſuſpenſion will move with an

accelerated motion, ſimilar to that of falling bodies, but as much ſlower, in proportion, very nearly, as the added weight is leſs than the whole weight borne by the fulcrum.

10. The ſtronger the tendency to an horizontal poſition in any balance, or the quicker its vibrations, § § 3, 5, the greater additional weight will be required to cauſe it to turn, or incline to any given angle. No balance therefore can turn ſo quick as the motion deduced in § 9. Such a balance as is there deſcribed, if it were to turn with the ten thouſandth part of the weight, would move at quickeſt ten thouſand times ſlower than falling bodies; that is, the diſh containing the weight, inſtead of falling through ſixteen feet in a ſecond of time, would fall through only two hundred parts of an inch, and it would require four ſeconds to move through one-third part of an inch: conſequently, all accurate weighing muſt be ſlow. If the indexes of two balances be of equal lengths, that index which is connected with the ſhorter balance will move proportionally quicker than the other. Long beams are the moſt in requeſt, becauſe they are thought to have leſs friction; this is doubtful: but the quicker angular motion, greater ſtrength, and leſs weight of a ſhort balance, are certainly advantages.

11. Very delicate balances are not only uſeful in nice experiments, but are likewiſe much more expeditious than others in common weighing. If a pair of ſcales with a certain load be barely ſenſible to the one-tenth of a grain, it will require a conſiderable time to aſcertain the weight to that degree of accuracy, becauſe the turn muſt be obſerved ſeveral times over, and is very ſmall. But if no greater accuracy were required, and ſcales were uſed which would turn with the hundredth of a grain, a tenth of a grain, more or leſs, would make ſo great a difference in the turn, that it would be ſeen immediately.

12. If a balance be found to turn with a certain addition, and is not moved by any ſmaller weight, a greater ſenſibility may be given to that balance, by producing a tremulous motion in its parts. Thus, if the edge of a blunt ſaw, a file, or other ſimilar inſtrument, be drawn along any part of the caſe or ſupport of a balance, it will produce a jarring, which will diminiſh the friction on the moving parts ſo much, that the turn will be evident with one-third or one fourth of the addition that would elſe have been required. In this way, a beam which would barely turn by the addition of one-tenth of a grain, will turn with the one-thirtieth or fortieth of a grain.

13. A balance whoſe horizontal tendency depends only on its own weight, as in § 3, will turn with the ſame addition, whatever may be the load; except ſo far as a greater load will produce a greater friction.

14. But a balance whoſe horizontal tendency depends only on the elevation of the fulcrum, as in § 5, will be leſs ſenſible the greater the load; and the addition requiſite to produce an equal turn will be in proportion to the load itſelf.

15. In order to regulate the horizontal tendency in ſome beams, the fulcrum is placed below the points of ſuſpenſion, as in § 4, and a ſliding weight is put upon the cock or index, by means of which the center of gravity may be raiſed or depreſſed. This is an uſeful contrivance.

16. Weights are made by a ſubdiviſion of a ſtandard weight. If the weight be continually halved, it will produce the common pile, which is the ſmalleſt number for weighing between its extremes, without placing any weight in the ſcale with the body under examination. Granulated lead is a very convenient ſubſtance to be uſed in this operation of halving, which however is very tedious. The readieſt way to ſubdivide ſmall weights, conſiſts in weighing a certain quantity of ſmall wire,

wire, and afterwards cutting it into ſuch parts, by meaſure, as are deſired; or the wire may be wrapped cloſe round two pins, and then cut aſunder with a knife. By this means it will be divided into a great number of equal lengths, or ſmall rings. The wire ought to be ſo thin, as that one of theſe rings may barely produce a ſenſible effect on the beam. If any quantity (as for example, a grain) of theſe rings be weighed, and the number then reckoned, the grain may be ſubdivided in any proportion, by dividing that number, and making the weights equal to as many of the rings as the quotient of the diviſion denotes. Then, if 750 of the rings amounted to a grain, and it were required to divide the grain decimally, downwards, $\frac{9}{10}$ would be equal to 675 rings, $\frac{8}{10}$ would be equal to 600 rings, $\frac{7}{10}$ to 525 rings, &c. Small weights may be made of thin leaf braſs. Jewellers foil is a good material for weights below the $\frac{1}{10}$ of a grain, as low as to $\frac{1}{1000}$ grain, and all lower quantities may be either eſtimated by the poſition of the index, or ſhewn by actually counting the rings of wire, whoſe value has been determined.

17. In philoſophical experiments, it will be found very convenient to admit no more than one dimenſion of weight. The grain is of that magnitude as to deſerve the preference. With regard to the number of weights the chemiſt ought to be provided with, writers have differed according to their habits and views. Mathematicians have computed the leaſt poſſible number with which all weights within certain limits might be aſcertained; but their determination is of little uſe. Becauſe, with ſo ſmall a number, it muſt often happen that the ſcales will be heavily loaded with weights, on each ſide, put in with a view only to determine the difference between them. It is not the leaſt poſſible number of weights which it is neceſſary an operator ſhould buy to effect his purpoſe, that we ought to enquire after, but the moſt convenient number for aſcertaining his enquiries with accuracy and expedition. The error of adjuſtment is the leaſt poſſible, when only one weight is in the ſcale; that is, a ſingle weight of five grains is twice as likely to be true, as two weights, one of three, and the other of two grains, put into the diſh to ſupply the place of the ſingle five; becauſe each of theſe laſt has its own probability of error in adjuſtment. But, ſince it is as inconſiſtent with convenience to provide a ſingle weight, as it would be to have a ſingle character for every number; and as we have nine characters, which we uſe in rotation, to expreſs higher values according to their poſition, it will be found very ſerviceable to make the ſet of weights correſpond with our numerical ſyſtem. This directs us to the ſet of weights as follows: 1000 grains, 900 g. 800 g. 700 g. 600 g. 500 g. 400 g. 300 g. 200 g. 100 g. 90 g. 80 g. 70 g. 60 g. 50 g. 40 g. 30 g. 20 g. 10 g. 9 g. 8 g. 7 g. 6 g. 5 g. 4 g. 3 g. 2 g. 1 g. $\frac{9}{10}$ g. $\frac{8}{10}$ g. $\frac{7}{10}$ g. $\frac{6}{10}$ g. $\frac{5}{10}$ g $\frac{4}{10}$ g. $\frac{3}{10}$ g. $\frac{2}{10}$ g. $\frac{1}{10}$ g. $\frac{9}{100}$ g. $\frac{8}{100}$ g. $\frac{7}{100}$ g. $\frac{6}{100}$ g. $\frac{5}{100}$ g. $\frac{4}{100}$ g. $\frac{3}{100}$ g. $\frac{2}{100}$ g. $\frac{1}{100}$ g. With theſe the philoſopher will always have the ſame number of weights in his ſcales as there are figures in the number expreſſing the weights in grains.

Thus 742.5 grains will be weighed by the weights 700, 40, 2, and $\frac{5}{10}$.

I ſhall conclude this chapter with an account of ſome balances I have ſeen or heard of, and annex a table of the correſpondence of weights of different countries.

Muſchenbroek, in his Cours de Phyſique (French tranſlation, Paris, 1769), tom. ii. p. 247, ſays, he uſed an ocular balance of great accuracy, which turned (trebuchoit) with $\frac{1}{10}$ of a grain. The ſubſtances he weighed were between 200 and 300 grains. His balance therefore weighed to the $\frac{1}{120000}$ part of the whole; and would aſcertain ſuch weights truly to four places of figures.

In the Philoſophical Tranſactions, vol. lxvi. p. 509, mention is made of two accurate

accurate balances of Mr. Bolton; and it is ſaid that one would weigh a pound, and turn with the $\frac{1}{10}$ of a grain. This, if the pound be avoirdupois, is $\frac{1}{70000}$ of the weight; and ſhews that the balance could be well depended on to four places of figures, and probably to five. The other weighed half an ounce, and turned with the $\frac{1}{100}$ of a grain. This is the $\frac{1}{24000}$ of the weight.

In the ſame volume, page 511, a balance of Mr. Read's is mentioned, which readily turned with leſs than one pennyweight, when loaded with 55 pounds, before the Royal Society; but very diſtinctly turned with four grains, when tried more patiently. This is about the $\frac{1}{96000}$ part of the weight; and therefore this balance may be depended on to five places of figures.

Alſo, page 576, a balance of Mr. Whitehurſt's weighs one pennyweight, and is ſenſibly affected with the $\frac{1}{20000}$ of a grain. This is the $\frac{1}{48000}$ part of the weight.

I have a pair of ſcales of the common conſtruction, § 8, made expreſsly for me by a ſkilful workman in London. With 1200 grains in each ſcale, it turns with the $\frac{1}{70}$ of a grain. This is the $\frac{1}{84000}$ of the whole; and therefore about this weight may be known to five places of figures. The proportional delicacy is leſs in greater weights. The beam will be near a pound troy; and when the ſcales are empty, it is affected by the $\frac{1}{1000}$ of a grain. On the whole, it may be uſefully applied to determine all weights between 100 grains and 4000 grains to four places of figures.

A balance belonging to Mr. Alchorne of the Mint, in London, is mentioned, vol. lxxvii. p. 205, of the Philoſophical Tranſactions. It is true to 3 grains with 15lb. an end. If theſe were avoirdupois pounds, the weight is known to the $\frac{1}{75000}$ part, or to four places of figures, or barely five.

A balance (made by Ramſden, and turning on points inſtead of edges) in the poſſeſſion of Dr. George Fordyce, is mentioned in the ſeventy-fifth volume of the Philoſophical Tranſactions. With a load of four or five ounces, a difference of one diviſion in the index was made by the $\frac{1}{1000}$ of a grain. This is the $\frac{1}{384000}$ part of the weight, and conſequently this beam will aſcertain ſuch weights to five places of figures, beſides an eſtimate figure.

I have ſeen a ſtrong balance in the poſſeſſion of my friend Mr. Magellan, of the kind mentioned in § 15, which would bear ſeveral pounds, and ſhewed the $\frac{1}{10}$ of a grain, with one pound an end. This is the $\frac{1}{70000}$ of the weight, and anſwers to five figures. But I think it would have done more by a more patient trial than I had time to make.

The Royal Society's balance, which was lately made by Ramſden, turns on ſteel edges, upon planes of poliſhed cryſtal. I was aſſured that it aſcertained a weight to the ſeven millionth part. I was not preſent at this trial, which muſt have required great care and patience, as the point of ſuſpenſion could not have moved over much more than the $\frac{2}{100}$ of an inch in the firſt half minute: but, from ſome trials which I ſaw, I think it probable that it may be uſed in general practice to determine weights to five places and better.

From this account of balances, the ſtudent may form a proper eſtimate of the value of thoſe tables of ſpecific gravities, which are carried to five, ſix, and even ſeven places of figures, and likewiſe of the theoretical deductions in chemiſtry that depend on a ſuppoſed accuracy in weighing, which practice does not authoriſe. In general, where weights are given to five places of figures, the laſt figure is an eſtimate, or gueſs figure; and where they are carried farther, it may be taken for granted that the author deceives either intentionally, or from want of ſkill in reducing his weights to fractional expreſſions, or otherwiſe.

Among the numerous public exertions which our learned neighbours, the French, have made in favour of the ſciences, the determination of the relative proportions of the weights uſed in various parts of Europe, is by no means one of the leaſt. The moſt exact ſtandard weights were procured by means of the ambaſſadors of France, reſident in various places; and theſe were compared by Monſ. Tillet with the ſtandard mark in the pile preſerved in the Cour de Monnoies de Paris. His experiments were made with an exact balance made to weigh one marc, and ſenſible to one quarter of a grain. Now, as the mark contains 18,432 quarter grains, it follows that his balance was a good one, and would exhibit proportions to four places, and a gueſs figure. The reſults are contained in the following table, extracted from Monſ. Tillet's excellent Paper in the Memoirs of the Royal Academy of Sciences for the year 1767. I have added the two laſt columns, which ſhew the number of French and Engliſh grains contained in the compound quantities againſt which they ſtand. The Engliſh grains are computed to one-tenth of a grain, although the accuracy of weighing came no nearer than about two-tenths.

Table of the Weights of different Countries.

Place and Denomination of Weight.	Marc.	oz.	gros.	grains.	F. grains.	E. grains.
Berlin. The marc of 16 loths	—	7	5	16	4408	3616.3
Berne. Goldſmiths weight of 8 ounces	1	—	½	4	4648	3813.2
Berne. Pound of 16 ounces, for merchandize	2	1	½	6	9834	8067.7
The common pound varies very conſiderably in other towns of the Canton.						
Berne. Apothecaries weight of 8 ounces	—	7	5½	26	4454	3654.
Bonn.	—	7	5	6¾	4398¾	3608.6
Bruſſels. The marc, or original troyes weight	1	—	—	21	4629	3797.6
Cologn. The marc of 16 loths	—	7	5	11	4403	3612.2
Conſtantinople. The cheki, or 100 drachms	1	2	3	28	6004	4925.6
Copenhagen. Goldſmiths weight, commonly ſuppoſed equal to the marc of Cologn	—	7	5½	10⅓	4438⅓	3641.2
Copenhagen. Merchants weight of 16 loths	1	—	1	22½	4702½	3857.9
Dantzick weight; commonly ſuppoſed equal to the marc of Cologn	—	7	5	3½	4395½	3606.
Florence. The pound (anciently uſed by the Romans)	1	3	½	20	6392	5244.
Genoa. The peſo ſottile	1	2	2½	30	5970	4897.7
Genoa. The peſo groſſo	1	2	3	5	5981	4906.7
Hamburgh weight; commonly ſuppoſed equal to the Cologn marc	—	7	5	7¾	4399¾	3609.4
Hamburgh. Another weight	—	7	7	23	4559	3740.2
Liege. The Bruſſels marc uſed; but the weight proved	1	—	—	24	4632	3800.1
Liſbon. The marc, or half pound	—	7	3½	34	4318	3542.4
London. The pound troy	1	4	1½	1	7021	5760.
London. The pound avoirdupoiſe	1	6	6½	6	8538	7004.5
Lucca. The pound	1	3	—	23¼	6359¼	5217.
Madrid. The marc royal of Caſtile	—	7	4	8	4328	3550.7
Malta. The pound	1	2	2½	21	5961	4890.4
Manheim. (The Cologn marc)	—	7	5	10¼	4402	3611.5
Milan. The marc	—	7	5	33	4425	3630.2
Milan. The libra groſſa	3	—	7½	—	14364½	11784.
Munich. (The Cologn marc)	—	7	5	11½	4403½	3612.3
Naples. The pound of 12 ounces	1	2	3½	27	6039	4954.3
Ratiſbon. The weight for gold: of 128 crowns	1	6	—	24	8088	6635.3
Ratiſbon. The weight for ducats: of 64 ducats	—	7	2	32	4208	3452.3
Ratiſbon. The marc of 8 ounces	1	—	—	24	4632	3800.1
Ratiſbon. The pound of 16 ounces	2	2	4½	6	10698	8776.5
Rome. The pound of 12 ounces	1	3	½	14	6386	5239.
Stockholm. The pound of 2 marcs	1	5	7	8	8000	6563.1
Stuttgard. (The Cologn marc)	—	7	5	11¾	4403¾	3612.6
Turin. The marc of 8 ounces	1	—	—	22¼	4630¼	3799.
At Turin they have alſo a pound of 12 of the above ounces. But, in their apothecaries pound of 12 ounces, the ounce is one ſixth lighter.						
Warſaw. The pound	1	5	2	12	7644	6271.
Venice. The libra groſſa of 12 ounces	1	7	4½	25½	8989½	7374.5
Venice. The peſo ſottile of 12 ounces	1	1	6½	24	5676	4656.5
In the pounds dependant on Venice, the pound differs conſiderably in each.						
Vienna. The marc of commerce	1	1	1	16	5272	4325.
Vienna. The marc of money	1	1	1	26	5282	4333.3
France. The grain	—	—	—	—	1.	1.21895
England. The grain	—	—	—	—	0.82039	1.

BALLS, MARTIAL. A medical compoſition, conſiſting of iron filings and cream of tartar, uſed to impregnate water, or other liquids, with iron diſſolved by the acid of tartar. To make theſe balls, one part of filings of iron and two parts of powdered cream of tartar are mixed well together, and put into an earthen or iron veſſel with ſome water. This mixture is to be ſtirred from time to time, until it becomes almoſt dry, and then it is to receive more water, and to be ſtirred as before. This treatment is to be continued until it acquires, when nearly dry, ſomewhat of the conſiſtence and tenacity of ſoftened reſin. Then it is to be rolled up into the form of a ball, which is generally kept tied up in a rag; and when intended to be uſed, it is to be infuſed in water until it gives ſome colour to that liquid.

In this compoſition, part of the acid of tartar, which is redundant in the cream of tartar, combines with part of the iron; and the remaining or greater part of the cream of tartar and iron continues ſolid in this way of proceeding. The infuſion of the martial ball in water does not therefore differ, as Macquer obſerves, from the tartarized tincture of iron. Its virtues are much the ſame as thoſe of other martial medicines. Theſe balls are unknown to us in England.

BALLS, MERCURIAL. Theſe conſiſt of an amalgam of tin and mercury, in which the former metal ſo far predominates, as to give the maſs a ſolid form. Macquer mentions the uſe of them by travellers to purify water, in which they are boiled for this purpoſe. I do not ſee, however, in what reſpect they would produce any material advantage. The mercurial impregnation, which the water would ſlightly receive from this treatment, does not ſeem likely to counteract in any conſiderable degree the bad qualities of another nature which may predominate in waters.

BALASS, *or* BALAIS RUBY. A precious ſtone of a pale red colour, inclining to violet. It comes chiefly from the Brazils; although ſome likewiſe come from the Eaſt Indies. The value of the Balaſs ruby is about thirty ſhillings per carat, according to Dutens.

BALLOON. Receivers of a ſpherical form are called Balloons by the French, and likewiſe by ſeveral tranſlators from that language.

BALLOON, AIR, *or* AEROSTATICAL. The firſt experiment for floating bodies in the atmoſphere, by including within them a fluid ſpecifically leſs heavy than common air, was made by Meſſrs. Stephen and John Mongolfier, at Avignon, in the month of November 1782. They raiſed a bag of ſilk, by inflating it with common air, heated or altered by combuſtion; it being evident that ſuch a bag muſt riſe on the ſame principle as ſmoke aſcends from a chimney. This experiment led ſeveral French philoſophers to the conſideration, that inflammable air, of which the great levity had been aſcertained by Mr. Cavendiſh in 1766, might with more permanent advantage be applied to this purpoſe; and accordingly M. Faujas St. Fond conſtructed a machine on this principle by public ſubſcription at Paris, which was ſuffered to riſe into the atmoſphere from the Champ de Mars, in the month of Auguſt 1783. Pilatre de Rozier firſt aſcended into the air with a balloon on Mongolfier's principle; and Meſſrs. Charles and Robert made the firſt experiment of aſcending with a balloon filled with inflammable air.

Cavallo's Treatiſe on the Hiſtory and Practice of Aeroſtation may be conſulted for an account of the methods of conſtructing and filling theſe machines. The moſt uſual means of obtaining the inflammable air has been to diſſolve iron ſhavings or turnings in diluted vitriolic acid; but it appears probable that the calcination

cination of ignited iron by ſteam would prove the cheapeſt, if the demand for machines of this kind were ever to become conſiderable.

BALSAM. The ſeveral vegetable principles in commerce have been diſtinguiſhed by various names which bear no relation to their properties, conſidered with regard to ſcientific arrangement. They have been uſually conſidered to be oily aromatic ſubſtances, imperfectly fluid, obtained from inciſions made in certain trees. Several French chemiſts, among whom are Fourcroy and Chaptal, have adopted the judicious diſtinction of Bucquet, who has confined this denomination to ſuch reſinous matters alone as poſſeſs a fragrant ſmell, and more eſpecially contain acid, odorant, and concrete ſalts, that may be extracted by decoction or ſublimation. The principal balſams, according to this diviſion, are benzoin, balſam of Tolu or Peru, and ſtorax, which ſee.

BALSAM OF SULPHUR. A ſolution of ſulphur in oil.

All oils, whether expreſſed or eſſential, can diſſolve ſulphur. To make this ſolution, the oil muſt be poured on the ſulphur, and ſufficient heat applied to melt the ſubſtance. While the oil diſſolves the ſulphur, it acquires a reddiſh or brown colour, an acrid, diſagreeable taſte, and a ſtrong fetid ſmell, ſomewhat hepatic, reſembling that of the combination of oil with vitriolic acid.

It is not well aſcertained what happens in this combination. The fixed oils depoſit ſulphur in the cryſtallized ſtate; but when the balſam of ſulphur is diſtilled, the ſulphur itſelf is totally decompoſed, or at leaſt it is no where found in a diſengaged ſtate. Homberg, by diſtillation with a very ſlow fire, obtained volatile ſulphureous acid, vitriolic acid of various degrees of ſtrength, ſome oil, partly fluid and partly thick, and a coaly reſidue, but no ſulphur. From this experiment it appears, that the acid principle of the oil acidifies a certain part of the ſulphur; and it is more than probable, that the inflammable air of the oil comes over in the hepatic form, in combination with another part of the ſulphur.

There is ſome danger of exploſion, when combinations of oil and ſulphur are too ſuddenly and conſiderably heated.

BARYTES. See EARTH, PONDEROUS.

BARBADOES TAR. Petroleum, long expoſed to the air, becomes converted into this ſubſtance. It is viſcid, brown, black, or reddiſh; is not ſoluble in ardent ſpirit; eaſily melts, and burns with much ſmoke. It contains a portion of acid of amber.

BASALTES. A dark grey or black ſtone, generally of a ferruginous appearance externally, and cryſtallized in large priſms, uſually hexagonal, but frequently conſiſting of a greater or leſs number of ſides. From the natural hiſtory of this ſtone it is well aſcertained to be a volcanic product, which has flowed in prodigious ſtreams during the eruptions of burning mountains, and afterwards cracked by cooling, and perhaps by the evaporation of ſome volatile ſubſtance, in the ſame manner as clays, ſtarch, and other ſubſtances are obſerved to crack. It has been a matter of controverſy among various mineralogiſts, whether the baſaltes has been formed in the humid or in the dry way. Either proceſs is perfectly conſiſtent with what we know of volcanic phenomena. The probability appears however to be in favour of thoſe chemiſts, who ſuppoſe baſaltes to owe its liquefaction to water; for although it is fuſible by fire, it then forms a ſubſtance of a very different appearance from that which has been ejected from the volcanos. In this laſt ſituation it forms a black glaſs.

Baſaltes is either found in irregular maſſes of all ſizes, ſometimes lamellated like ſlate, and of large dimenſions, and at other times forming ſolid blocks. But the moſt

moſt remarkable is the columnar baſaltes, which forms immenſe maſſes, compoſed of columns, thirty, forty, or more feet in height, and of enormous thickneſs. Theſe conſtitute ſome of the moſt aſtoniſhing ſcenes in nature for the immenſity and regularity of their parts. The coaſt of Antrim in Ireland, for the ſpace of three miles in length, exhibits a moſt magnificent variety of columnar cliffs; and the Giants Cauſeway conſiſts of a point of that coaſt formed of ſimilar columns, and projecting into the ſea upon a deſcent for ſeveral hundred feet. Theſe columns are, for the moſt part, hexagonal, and fit very accurately together, being in ſome inſtances united by a ſtony cement, but moſt frequently not adherent to each other. And the baſaltic appearances on the Hebrides iſlands on the coaſt of Scotland, as deſcribed by Sir Joſeph Banks, who viſited them in 1772, are upon a ſcale ſtill more ſtriking for its vaſtneſs and variety.

An extenſive field of enquiry is here offered to the geological philoſopher in his attempts to aſcertain the alterations to which the globe has been ſubjected. The enquiries of the chemiſt equally co-operate in theſe reſearches, and tend likewiſe to ſhew what uſeful purpoſes this and other ſubſtances may be applied to. Bergmann found that the component parts of various ſpecimens of baſaltes were, at a medium, 52 parts ſilex, 15 pure clay, 8 chalk, or mild calcareous earth, and 25 iron. The differences ſeem however to be conſiderable; for Faujas de St. Fond gives theſe proportions:—46 ſilex, 30 clay, 10 lime, 6 magneſia, and 8 iron.

BASIS, *or* BASE. The chemical philoſophers have for a long time been in the habit of conſidering the acids as bodies poſſeſſing an activity peculiar to themſelves; and have, in general, overlooked the circumſtance, that an equal activity, or power of attraction, muſt exiſt in thoſe ſubſtances with which they combine, and are by that means deprived of their diſtinctive properties. The ſubſtances with which acids enter into combination, and are ſaid to be neutralized, are for the moſt part leſs volatile than the acids themſelves; and accordingly communicate a degree of fixity to thoſe acids. From both theſe reaſons, writers have been led to diſtinguiſh the ſubſtance which is united with any acid, by the name of the baſis of the compound, or neutral ſalt. As a conſiderable advantage, with regard to chemical language, is obtained from the uſe of this term, which is not altogether improper, it is ſtill much uſed by chemical authors. Thus, we ſay, ſalts with earthy baſes, ſalts with alkaline baſes, or ſalts with metallic baſes, accordingly as the caſe may be; by which it is to be underſtood that theſe ſubſtances are united with an acid. And ſo, likewiſe, the expreſſions, vitriolic ſalt with baſis of clay, nitrous ſalt with baſis of vegetable alkali, marine ſalt with baſis of iron, and other ſimilar expreſſions, are uſed to advantage by chemical writers who wiſh to deſcribe combinations, and at the ſame time to avoid the uſual names which in many inſtances refer to theories either exploded or doubtful.

BATH. The heat communicated from bodies in combuſtion, muſt neceſſarily vary according to circumſtances; and this variation not only influences the reſults of operations, but in many inſtances endangers the veſſels, eſpecially if they be made of glaſs. Among the ſeveral methods of obviating this inconvenience, one of the moſt uſual conſiſts in interpoſing a quantity of ſand, or other matter, between the fire and the veſſel intended to be heated. The ſand bath and the water bath are moſt commonly uſed; the latter of which is called Balneum Mariæ by the elder chemiſts. A bath of ſteam may in ſome inſtances be found preferable to the water bath. Some chemiſts have propoſed baths of melted lead, of tin, and of other fuſible ſubſtances. Theſe may perhaps be found advantageous in a few

peculiar operations, in which the intelligent operator muſt indeed be left to his own ſagacity.

The water bath is nothing more than a pot or veſſel containing water, which is kept boiling, and in which the digeſting or diſtillatory veſſels are kept immerſed. As the heat of boiling water is nearly ſtationary, this temperature is found very advantageous in the diſtillation of eſſential oils, and all other ſubſtances in which an empyreumatic taint is to be feared. It may eaſily be imagined that the form of the bath, as well as of the veſſels, may be varied according to the purpoſes reſpectively aimed at.

The ſand bath conſiſts of ſand placed either in an iron pot, or upon an iron hearth with fire underneath. In this the heat is gradually communicated, although leſs uniformly than by the water bath; and it may likewiſe be carried to ignition. As the heat is greateſt towards the bottom of the ſand, the operator poſſeſſes a power of moderating it by raiſing the veſſel when neceſſary. The extenſive ſand bath which is formed by ſpreading ſand upon an iron hearth, is very uſeful for digeſtion, ſolution, evaporation, and other chemical proceſſes, which may be carried on at the ſame time in a conſiderable number of veſſels.

BDELLIUM. A gum reſin, ſuppoſed to be of African origin. The beſt bdellium is of a yellowiſh brown, or dark brown colour, according to its age; unctuous to the touch, brittle, but ſoon ſoftening, and growing tough betwixt the fingers; in ſome degree tranſparent, not unlike myrrh; of a bitteriſh taſte, and a moderately ſtrong ſmell. It does not eaſily take flame, and when ſet on fire ſoon goes out. In burning, it ſputters a little, owing to its aqueous humidity; but cannot be ſaid to explode, much leſs to explode like gunpowder, as Herman Valentini reports.

An ounce of picked bdellium, treated with water, afforded Neumann ſix drams two ſcruples of gummy extract; and afterwards, with ſpirit, two ſcruples of reſin, two ſcruples remaining undiſſolved. Another ſcruple, treated firſt with rectified ſpirit, yielded two drams of reſinous extract; and afterwards, with water, five drams two ſcruples of gum, only one ſcruple remaining undiſſolved. The diſtilled ſpirit has no taſte or ſmell of the bdellium, and the diſtilled water very little.

BEE-GLEW. A ſoft unctuous glutinous matter, uſed by the bees for cementing the combs to the hives, and cloſing up the cells. Neumann ſeems to conſider it as different from the wax; but I do not find that any experiments have been made upon it.

BEER is the wine of grain. Malt is uſually made of barley. The grain is ſteeped for two or three days in water until it ſwells, becomes ſomewhat tender, and tinges the water of a bright reddiſh brown colour. The water being then drained away, the barley is ſpread about two feet thick upon a floor, where it heats ſpontaneouſly, and begins to grow, by firſt ſhooting out the radicle. In this ſtate, the germination is ſtopped by ſpreading it thinner, and turning it over for two days; after which it is again made into an heap, and ſuffered to become ſenſibly hot, which uſually happens in little more than a day. Laſtly, it is conveyed to the kiln, where, by a gradual and low heat, it is rendered dry and criſp. This is malt; and its qualities differ according as it is more or leſs ſoaked, drained, germinated, dried, and baked. In this, as in other manufactories, the intelligent operators often make a myſtery of their proceſſes, from views of profit; and others pretend to peculiar ſecrets, who really poſſeſs none.

Indian corn, and probably all large grain, require to be ſuffered to grow into the blade,

blade, as well as root, before it is fit to be made into malt. For this purpoſe, it is buried about two or three inches deep in the ground, and covered with looſe earth; and in ten or twelve days it ſprings up. In this ſtate, it is taken up and waſhed, or fanned, to clear it from its dirt; and then dried in the kiln for uſe.

Beer is made from malt previouſly ground, or cut in pieces, by a mill. This is placed in a tun, or tub with a falſe bottom; hot water is poured upon it, and the whole ſtirred about with a proper inſtrument. The temperature of the water in this operation, called Maſhing, muſt not be equal to boiling; for, in that caſe, the malt would be converted into a paſte, from which the impregnated water could not be ſeparated. After the infuſion has remained for ſome time upon the malt, it is drawn off, and is then diſtinguiſhed by the name of Sweet Wort. By one or more ſubſequent infuſions of water, a quantity of weaker wort is made, which is either added to the foregoing, or kept apart, according to the intention of the operator. The wort is then boiled with hops, which gives it an aromatic bitter taſte, and is ſuppoſed to render it leſs liable to be ſpoiled in keeping; after which it is cooled in ſhallow veſſels, and ſuffered to ferment, with the addition of a proper quantity of yeaſt. The fermented liquid is beer; and differs greatly in its quality, according to the nature of the grain, the malting, the maſhing, the quantity and kind of the hops and the yeaſt, the purity or admixtures of the water made uſe of, the temperature and viciſſitudes of the weather, &c.

BELLY. When a metallic ore is found, not in veins, but diſtinct maſſes, theſe are called Bellies or Stock Works by the miners. In the iron founderies, likewiſe, the large air veſſels which receive the air from iron bellows, worked by ſteam engines, and tranſmit it in an equal ſtream to the furnace by the re-action of water, are called by the workmen Regulating Bellies.

BELL-METAL. The baſis of the compoſition called Bell-metal, is copper, which is alloyed chiefly with tin. Silver is ſaid to be ſometimes added. A ſmall proportion of tin, added to copper, deprives it of its malleability ſo far as to render it quite brittle; and the ſpecific gravity of the compound is always greater than would be deduced by computation from the quantities and ſpecific gravities of its component parts. In certain proportions, it even exceeds that of the heavier metal. The colour of bell-metal is much whiter than might be expected from the proportion of tin which enters into its compoſition; and when this laſt metal conſtitutes one-third of the maſs, the compound is ſo perfectly white, as to reflect the images of all coloured bodies without alteration, when duly poliſhed. See SPECULUM.

BEN, OIL OF. This is obtained from the ben nut, by ſimple preſſure. It is remarkable for its not growing rancid in keeping, or at leaſt not until it has ſtood for a number of years; and, on this account, it is uſed in extracting the aromatic principle of ſuch odoriferous flowers as yield little or no eſſential oil in diſtillation. Theſe preparations are made in Spain, Portugal, and more eſpecially Italy, by the following method, according to Neumann:—Some fine carded cotton is dipped in oil, and laid in the bottom of a proper veſſel: on this is ſpread a pretty thick layer of freſh flowers, above theſe ſome more of the dipped cotton; and thus alternately till the veſſel is full. The whole is then digeſted, for a day and a night, in the heat of a water bath; after which the flowers are taken out, the cotton ſtratified in the ſame manner with freſh flowers, and the proceſs repeated until the oil ſqueezed out from the cotton is found to be ſufficiently impregnated with the odour of the ſubject. The digeſting veſſel is either of tin, with a cover to ſcrew upon it; or of porcelain, compoſed of two parts, which are cloſely luted together. Moſt

of

of them have an air-hole in the top, which is ſtopped with a doſſil of the oiled cotton, which retains ſuch of the odorous effluvia as would otherwiſe make their eſcape. Some, inſtead of the oil of ben, take the ben itſelf, cut it in pieces, ſtratify it repeatedly with the flowers, and then preſs out its oil; but the oil thus obtained is greatly inferior in fragrance to the other.

BENJAMIN, *or* BENZOIN. The tree which produces benzoin is a native of the Eaſt Indies, particularly of the iſland Siam and Sumatra *. The juice exſudes from inciſions, in the form of a thick white balſam. If collected as ſoon as it has grown ſomewhat ſolid, it proves internally white like almonds, and hence it is called Benzoë Amygdaloides: if ſuffered to lie long expoſed to the ſun and air, it changes more and more to a browniſh, and at laſt to a quite reddiſh brown colour. The dealers in this commodity never ſell us the fine white benzoin by itſelf, but mix it with the inferior and fouler kinds, that one may carry off the other. Hence in the very beſt benzoin of the ſhops, we meet with pieces of various colours—white, yellowiſh white, yellow, browniſh yellow, brown, reddiſh brown, and grey, all united in one lump. The dark-coloured benzoin, however, if it is free from earth and woody impurities, and from admixtures of any other reſin, does not appear to be inferior in goodneſs to the white.

This reſin is moderately hard and brittle, and yields an agreeable ſmell when rubbed or warmed. It is totally ſoluble in ardent ſpirit; from which, like other reſins, it may be precipitated by the addition of water.

The white opake fluid thus obtained has been called Lac Virginale; and is ſtill ſold, with other fragrant additions, by perfumers as a coſmetic. Trituration with water ſeparates a ſmall quantity of the peculiar ſalt or acid of benzoin. See ACID OF BENZOIN.

BERYL. A precious ſtone of a blue green colour, by many authors confounded, and perhaps juſtly, with the aqua marine. Cronſtedt however calls the lighter-coloured ſtone Aqua Marine, and the darker the Beryl. See AQUA MARINE.

BEZOAR MINERAL. This preparation is a calx of antimony, produced by diſtilling the nitrous acid ſeveral times to dryneſs from the butter of antimony, which is a combination of dephlogiſticated marine acid and regulus of antimony. Much air eſcapes during the diſtillation, which may be preſumed to conſiſt chiefly of the aëriform dephlogiſticated marine acid, with nitrous and phlogiſticated air. Experiments however are wanting. It is not probable that the remaining calx, or bezoar mineral, poſſeſſes any properties different from thoſe of any other well-prepared calx of this ſemi-metal.

BISMUTH is a ſemi-metal of a yellowiſh or reddiſh white colour, little ſubject to change in the air. It is ſomewhat harder than lead, and is ſcarcely, if at all, malleable; being eaſily broken, and even reduced to powder, by the hammer. The internal face, or place of fracture, exhibits large ſhining plates, diſpoſed in a variety of poſitions; thin pieces are conſiderably ſonorous. At a temperature not exceeding the 460th degree of Fahrenheit, it melts; and its ſurface becomes covered with a greeniſh-grey or brown calx. A ſtronger heat ignites it, and cauſes it to burn with a ſmall blue flame; at the ſame time that a yellowiſh calx, known by the name of Flowers of Biſmuth, is driven up. This calx appears to riſe in conſequence of the combuſtion; for it is very fixed, and runs into a greeniſh glaſs

* Conſult the Philoſophical Tranſactions, vol. lxxvii. page 307, for a botanical deſcription and drawing of the tree.

when expoſed to heat alone. Biſmuth urged by a ſtrong heat in a cloſed veſſel, ſublimes entire. This ſemi metal cryſtallizes very diſtinctly when gradually cooled.

The vitriolic acid has a ſlight action upon biſmuth when it is concentrated and boiling. Vitriolic acid air is exhaled, and part of the biſmuth is converted into a white calx. A ſmall portion combines with the vitriolic acid, and affords a deliqueſcent ſalt in the form of ſmall needles.

The nitrous acid diſſolves biſmuth with the greateſt rapidity and violence; at the ſame time that much heat is extricated, and a large quantity of nitrous air eſcapes. The ſolution, when ſaturated, affords cryſtals as it cools; the ſalt detonates weakly, and leaves a yellow calx behind, which effloreſces in the air. Upon diſſolving this ſalt in water, it renders that fluid of a milky white, and lets fall a calx of the ſame colour.

The nitrous ſolution of biſmuth exhibits the ſame property when diluted with water, moſt of the metal falling down in the form of a white calx, called Magiſtery of Biſmuth. This precipitation of the nitrous ſolution, by the addition of water, is the criterion by which biſmuth is diſtinguiſhed from all other metals. The magiſtery or calx is a very white and ſubtile powder; when prepared by the addition of a large quantity of water, it is uſed as a paint for the complexion, and is thought gradually to impair the ſkin. The liberal uſe of any paint for the ſkin ſeems indeed likely to do this; but there is reaſon to ſuſpect, from the reſemblance between the general properties of lead and biſmuth, that the calx of this ſemi-metal may be attended with effects ſimilar to thoſe which the calces of lead are known to produce.

The marine acid does not readily act upon biſmuth. It is neceſſary that the acid ſhould be concentrated, and kept a long time in digeſtion upon it; or that it ſhould be diſtilled from the ſemi-metal. The reſidue, when waſhed with water, affords a ſaline combination, which does not eaſily cryſtallize, but may be ſublimed in the form of a ſoft fuſible ſalt, called Butter of Biſmuth. The marine ſolution of biſmuth likewiſe affords a precipitate of calx by the addition of water. Marine acid ſeizes the calx of biſmuth, when added to its ſolution in nitrous acid, and forms a compound of ſparing ſolubility, which falls to the bottom. Alkalis likewiſe precipitate its calx; but not of ſo beautiful a white colour as that afforded by the affuſion of pure water.

The effects of earths and alkalis upon biſmuth, in the dry way, have been little attended to. Nitre calcines it, with ſcarcely any perceptible detonation. Sal ammoniac is not decompoſed by biſmuth in the metallic ſtate, although its calx readily combines with the marine acid of that ſalt, and diſengages the volatile alkali. Sulphur unites with biſmuth by fuſion, and forms a blueiſh grey brilliant maſs, of a needle-formed texture.

This ſemi-metal unites with moſt metallic ſubſtances, and renders them in general more fuſible. When calcined with the imperfect metals, its glaſs diſſolves them, and produces the ſame effect as lead in cupellation; in which proceſs it is even ſaid to be preferable to lead.

Biſmuth is uſed in the compoſition of pewter, in the fabrication of printers types, and in various other metallic mixtures.

It is ſometimes found native; and may be analyſed in the humid way by ſolution in nitrous acid, and precipitation by the addition of water, which throws down one hundred and thirteen grains of calx for every hundred of metallic biſmuth. It is likewiſe found in the calciform ſtate; and mineralized by ſulphur,

of a grey colour, reſembling galena, but heavier. Theſe ores may alſo be analyſed by nitrous acid, like the foregoing.

Biſmuth is eaſily ſeparable, in the dry way, from its ores, on account of its great fuſibility. It is uſual, in the proceſſes at large, to throw the biſmuth ore into a fire of wood; beneath which a hole is made in the ground to receive the metal, and defend it from calcination. The ſame proceſs may be imitated in the ſmall way, in the examination of the ores of this metal; nothing more being neceſſary than to expoſe it to a moderate heat in a crucible, with a quantity of reducing flux; taking care, at the ſame time, to perform the operation as ſpeedily as poſſible, that the biſmuth may be neither calcined nor volatilized.

BISTRE. A brown pigment, conſiſting of the finer parts of wood-ſoot, ſeparated from the groſſer by waſhing.

BITTERN. The mother water which remains after the cryſtallization of common or marine ſalt in ſea water, or the water of ſalt ſprings. It abounds with Epſom ſalt, or the combination of vitriolic acid with magneſia, to which its bitterneſs is owing. *See* WATER (SEA).

BITUMEN. This word is uſed with ſome latitude by chemical writers. By ſome it is applied to ſuch mineral ſubſtances as are of an oily nature, whether they be found in the ſolid or the fluid ſtate; others apply it only to the ſolid inflammable ſubſtances of this kingdom, excepting only ſulphur. It may perhaps be moſt convenient to uſe this term in denoting all mineral inflammable ſubſtances, found in the ſolid or fluid ſtate, not coming under the denomination of earths, ſalts, acidifiable baſes, or metallic ores. Kirwan, to whoſe arrangement we ſhall principally adhere in the preſent article, obſerves that the ſolid bitumens never exceed 2,5 in ſpecific gravity. In the following ſhort enumeration, we ſhall include inflammable air, hepatic air, ſulphur, phoſphorus, and plumbago; by which means it will exhibit a tolerably complete ſeries of mineral inflammables. The articles themſelves may be conſulted for a fuller account of their reſpective properties. The inflammable ſubſtances found in the mineral kingdom are—1. Inflammable air, called Fire Damp in the mines. 2. Hepatic air, which abounds in many hot-baths, in mines, and in the neighbourhood of volcanos. 3. Naphtha; a fine white, thin, fragrant, colourleſs oil, which iſſues out of white, yellow, or black clays in Perſia and Media. This is highly inflammable, and is decompoſed by diſtillation. It diſſolves reſins, and the eſſential oils of thyme and lavender; but is not itſelf ſoluble either in ſpirit of wine or ether. It is the lighteſt of all the denſe fluids, its ſpecific gravity being 0,708. 4. Petroleum, which is a yellow, reddiſh, brown, greeniſh, or blackiſh oil, found dropping from rocks, or iſſuing from the earth, in the duchy of Modena, and in various other parts of Europe and Aſia. This likewiſe is inſoluble in ſpirits of wine, and ſeems to conſiſt of naphtha, thickened by expoſure to the atmoſphere. It contains a portion of the acid of amber. 5. Barbadoes tar, which is a viſcid, brown, or black inflammable ſubſtance, inſoluble in ſpirit of wine, and containing the acid of amber. This appears to be the mineral oil in its third ſtate of alteration. 6. Aſphaltum is a ſmooth, hard, brittle, inflammable ſubſtance, which melts eaſily, and burns without leaving any aſhes, if it be pure. It is ſlightly and partially acted on by ſpirit of wine and ether. 7. Mineral tallow, which is a white ſubſtance of the conſiſtence of tallow, and as greaſy, although more brittle. It was found in the ſea on the coaſts of Finland, in the year 1736; and is alſo met with in ſome rocky parts of Perſia. It is near one-fifth lighter than tallow; burns with a blue flame, and a ſmell of greaſe, leaving a black viſcid matter behind, which is more difficultly con-

ſumed. 8. Jet, which is much harder than aſphaltum; ſuſceptible of a good poliſh, and gloſſy in its fracture. It is highly electrical, fuſible in a moderate heat, and inſoluble in ſpirit of wine. 9. Pit-coal. Of this there are many varieties; they appear to conſiſt of petroleum, conſolidated with an earth, chiefly of the argillaceous kind. 10. Peat is a black inflammable earth, which is of a viſcid conſiſtence when freſh, but hardens by expoſure to the air. 11. Turf conſiſts of mould interwoven with roots of vegetables. 12. Amber is inſoluble in water, and in ſpirit of wine; and no other acid but the vitriolic diſſolves it. By diſtillation, it affords a ſmall portion of water, an oil of the nature of petroleum, and a peculiar acid. 13. Sulphur is very abundant in the mineral kingdom. 14. Phoſphorus has not hitherto been found in the mineral kingdom, except in combination with lome, and ſome of the metals. 15. Plumbago, or black-lead.

When we attend to the inflammable ſubſtances found in the earth, or in the mineral kingdom, we may perceive that very few, and moſt probably none of them, can be truly ſaid to belong to it, but have been elaborated in the bodies of animals or vegetables. From the turf that is pared from the ſurface of the earth, and owes its inflammability to the roots of vegetables which are mixed with it, we may deſcend to the peat, or black earth of the moors; in many ſpecimens of which, vegetable remains are ſtill perceptible; although in moſt they appear to be deprived of every appearance of their organic texture, their oily and inflammable nature only remaining: and from thence the tranſition to pit-coal is eaſy. For if we reflect on the vaſt revolutions which the earth has certainly undergone through a long courſe of ages, by means of which its ſurface has been broken, diſplaced, and inverted, from the actions of floods, earthquakes, and the great convulſions of nature, cauſed by volcanic eruptions, it will be no improbable inference that the thin although extenſive ſtrata of pit-coal, as well as the exſudations of naphtha, petroleum, and their modifications, have all ariſen from the burying of extenſive woody tracts of the ſurface, ſuch as are common in all uncultivated countries. And this probability will be reduced to a certainty, when we advert to the natural hiſtory of pit-coal, which is met with in all the various ſtates of transformation. Whole trees are converted into pit-coal in ſuch quantities together, as to exhibit entire foreſts, in which the roots, trunks, branches, bark, and even ſpecies, are diſcernible. Coal pits and ſlate quarries exhibit innumerable marks of impreſſions of leaves, and other indications of their vegetable origin; and the analyſis of this combuſtible ſubſtance tends ſtill further to confirm this truth. On the other hand, if we attend to ſuch inſtances as chemical theory might point out from the facts around us, we ſhall ſee how ſmall the probability is, that the mineral kingdom ſhould, after a certain limited time, contain inflammable bodies, if they were not occaſionally thrown into it in conſequence of the operations carried on within organized ſubſtances. For all inflammable ſubſtances tending to decompoſe the vital air of the atmoſphere, would, in proceſs of time, revert to the claſs of uninflammable bodies, if the operation of the organized bodies, particularly of the vegetable kind, did not tend to diſengage the vital air again, and render bodies combuſtible which were not ſo when they became parts of thoſe ſubſtances.

BLACKNESS. Lewis, in his Philoſophical Commerce of Arts, has given a hiſtory of the means of producing black colours. Since blackneſs, in general, is the conſequence of a defect of light, any circumſtance which prevents the reflection of moſt of the luminous rays which fall upon bodies, will cauſe ſuch bodies to exhibit what is commonly called a Black Colour. Opticians have ſhewn that this effect

effect may arise either from the exquisite polish of bodies, which causes all the light to be reflected in one direction; or from the smallness of the primary particles, which transmit the light to the internal part of the body, instead of reflecting it. In this way, we find that all metallic substances, and likewise several other bodies, may be rendered black by mere mechanical trituration; and it is on account of the smallness of the particles that black pigments are capable of completely covering and destroying the effect of other colours. The substances described by Lewis, are—1. The black chalk of the shops, which seems to consist of an argillaceous earth, impregnated with bituminous matter, reduced to the state of coal. 2. Pit-coal, which affords a brown black, and is not easily ground to a sufficient fineness. 3. The black ferruginous sands, which are of little use as pigments. 4. Plumbago, or black lead, used for pencils. 5. Black vegetable juices; of which he enumerates the anacardium, or marking nut, from the East Indies, the juice of which stains linen or cotton of a reddish brown colour, that soon changes to a black, not to be discharged by alkalis; the Cashea nut, which affords a browniſh durable stain; and various species of the toxicodendron, or poison tree, from North America, which produces a deep black permanent stain. 6. The cuttle fish ink, or black fluid contained in a peculiar vessel of that animal; but whether this ink was of considerable value for its permanency, he had no opportunity of ascertaining.

Among the blacks produced by fire, the Doctor found that the coals of wood, and of animal substances, possess various properties, according to their nature, or original texture, when used as crayons or as pigments. The soot blacks are in general much softer, and more easily unite with oils. Several of the metals, such as manganese, cobalt, and iron, are of a black colour in certain states of calcination. On the subject of blackness, *See* INK, VARNISH, and DYING.

BLACK JACK. The miners distinguish blende, or mock lead, by this name. It is an ore of zinc, containing that metal in combination with iron and sulphur, and occasionally other ingredients.

BLACK LEAD. *See* PLUMBAGO.

BLACK WADD. One of the most remarkable ores of manganese. It is of a dark brown colour, partly in powder, and partly indurated and brittle. If half a pound of it be dried before a fire, and afterwards suffered to cool for about an hour, and then two ounces of linseed oil be gradually poured on it, mixing the whole loosely, like barm with flour, little clots will be formed: and, in something more than half an hour, the whole will grow hot, and at last burst into a flame. The temperature of the room, where this experiment was repeated, was about 30 degrees of Fahrenheit; and the heat this ore was exposed to, while drying, might be about 130 degrees.

According to Wedgwood's analysis, 100 parts of black wadd contain 43 of manganese, as much of iron, 4,5 of lead, and near 5 of micaceous earth.

BLEACHING is the art of rendering the various kinds of thread, cloths, &c. white, by depriving them of the colour they usually possess in their original state. In this article I shall first describe the usual, or old processes *, and then proceed to the improvements which modern chemistry has made in the art.

The method of bleaching silk.—The silk, being still raw, is put into a bag of thin linen, and thrown into a vessel of boiling river water, in which has been dissolved good Genoa or Toulon soap.

* From Postlethwaite.

After

After the ſilk has boiled two or three hours in that water, the bag being frequently turned, it is taken out to beat, and is then waſhed in cold water. When it has been thus thoroughly waſhed and beaten, they wring it ſlightly, and put it for the ſecond time into the boiling veſſel, filled with cold water, mixed with ſoap and a little indigo; which gives it that blueiſh caſt commonly obſerved in white ſilk.

When the ſilk is taken out of this ſecond water, they wring it hard with a wooden peg, to preſs out all the water and ſoap; after which they ſhake it to untwiſt it, and ſeparate the threads. Then they ſuſpend it in a kind of ſtove, conſtructed for that purpoſe, where they burn ſulphur; the vapour of which gives the laſt degree of whiteneſs to the ſilk.

The method of bleaching woollen ſtuffs.—There are three ways of doing this. The firſt is with water and ſoap; the ſecond with the vapour of ſulphur; and the third with chalk, indigo, and the vapour of ſulphur.

Bleaching with ſoap and water.—After the ſtuffs are taken out of the fullers mill, they are put into ſoap and water, a little warm, in which they are again worked by the ſtrength of the arms over a wooden bench: this finiſhes; giving them the whitening which the fullers mill had only begun. When they have been ſufficiently worked with the hands, they are waſhed in clear water, and put to dry.

This method of bleaching woollen ſtuffs, is called the Natural Method.

Bleaching with ſulphur.—They begin with waſhing and cleaning the ſtuffs thoroughly in river water; then they put them to dry upon poles or perches. When they are half dry, they ſtretch them out in a very cloſe ſtove, in which they burn ſulphur; the vapour of which, diffuſing itſelf, adheres by degrees to the whole ſtuff, and gives it a fine whitening; this is commonly called Bleaching by the Flower, or Bleaching of Paris, becauſe they uſe this method in that city more than any where elſe.

Bleaching with chalk, indigo, and ſulphur.—When the ſtuffs have been well waſhed in clear water, they throw them into a bucket of cold water, containing chalk and a little indigo, wherein the ſtuffs are well ſtirred and agitated: then they take them out, and waſh them again in clear water; after which they hang them on poles: when they are half dry, they put them into a ſtove to receive the vapour of ſulphur, which finiſhes their perfect whitening.

This bleaching, which is not the beſt, though very agreeable to the eye, is called Bleaching of Beauvais; becauſe the inhabitants of that city were the firſt who practiſed this method of bleaching woollen ſtuffs.

It muſt be obſerved that, when woollen ſtuffs have once imbibed the vapour of ſulphur, it is a difficult matter to make them take a good colour in dying, unleſs it be a black or blue.

The manner of bleaching fine linen cloths, with the method of preparing them, as practiſed in Picardy, and particularly near St. Quintin.—After the linens are taken from the loom, they are put to ſoak in clear water for a whole day: when they have been well waſhed and cleaned, they are taken out, and thrown into a bucking tub filled with cold lye, made of wood aſhes and water, which has been uſed in former proceſſes.

When they are taken out of that lye, they are waſhed again in clear water, and ſpread in a meadow, where they are occaſionally watered with clear water out of ſmall canals, made for that purpoſe in the grounds. They water them with ſcoops, or hollow and narrow wooden peels, with a long handle.

After lying a certain time on the ground, they paſs them through a freſh lye, poured

poured on hot: this lye is of different ſtrength, according to the quality of the linens.

Being taken out of this ſecond lye, they are waſhed in clear water, and laid again in the meadow; all which ſeveral operations are repeated until the linen has acquired the deſired degree of whiteneſs.

They are afterwards put into a weak lye, to reſtore the ſoftneſs which the preceding ſtrong lyes had deprived them of; and afterwards they waſh them in clear water.

They next rub them with black ſoap, which finiſhes whitening the ſelvages, which would never become perfectly white without the help of ſoap.

Then they waſh them well, to take off all the ſoap, and put them to ſoak in ſour cows milk, the cream being firſt taken off. This perfects their bleaching, gives them all their ſoftneſs, and makes them caſt a little nap. Being taken out of the milk, they are waſhed again in clear water, for the laſt time. When they have undergone all theſe operations, they give them the firſt blue; that is to ſay, they dip them into water in which a little ſtarch has been diſſolved, together with ſmalt, or Dutch lapis, of which the fatteſt and paleſt is the beſt, for the linens muſt not have too blue a caſt.

The linens being thus bleached, after the manner we have related, the bleachers or whiteners deliver them into the hands of the merchants to whom they belong, who cauſe them to be properly made up.

Theſe preparations differ according to the qualities of the linens: for there are ſome which ought to preſerve all their ſtrength; and others whoſe ſtrength muſt be diminiſhed, in order to render them clearer.

Lawns or cambrics are prepared with ſtarch and pale blue, or ſmalt diluted with clear water. They add ſome other drugs, the quantity and quality of which depend on the workmen's knowledge and capacity.

Being thus prepared, they are faſtened with ropes to poles fixed in the ground at ſome diſtance from each other. When they are three quarters or half dry, they take them from the poles, and beat them on marble blocks, with very ſmooth wooden mallets, which is done to beat down the grain, and give them a more beautiful appearance.

After this, they fold them into ſmall ſquares, and preſs them. When they come out of the preſs, the dealers in France put their numbers upon them, which are written or ſtamped upon ſmall pieces of parchment, and tied to the ſelvage of the piece with ſilk of different colours, according to the merchant's fancy, who calls that ſilk his livery; each merchant having his particular colour, which he never changes.

After this, they wrap up the pieces very neatly in brown paper of Rouen, well beat, tied with ſmall packthread, which they commonly get from Holland. The linens are then in a proper condition to be ſold, packed up, and ſent to the places where they are diſpoſed of.

All the clear linens of Picardy, ſuch as plain, ſtriped, or ſpotted lawns, are prepared after the ſame manner as thoſe before mentioned; except that theſe are beaten, but thoſe of Picardy are not.

It muſt be obſerved that, the fairer the weather is, the eaſier are the linens bleached. In fair weather they may be bleached in a month's time; but, in foul weather, ſix weeks, or more, are hardly ſufficient to complete the operation.

It muſt alſo be obſerved, that all the linens, of whatſoever kind they be, which are bleached in Holland, Flanders, and Picardy, are dipped in cows milk after

ater the cream is taken off; it being certain that it is this liquor which gives them that delicate whiteneſs ſo much admired in the linens which come from thoſe different countries.

It is cuſtomary with the merchants who ſend their linens to the bleaching grounds of Flanders and Picardy, to mark them at each end with one or more letters of their names (which marks are made with thread of Epinay, worked with the needle); and to faſten at the places where theſe marks are put, ſome ſmall twiſts, made alſo of the ſame thread of Epinay; which twiſts have a certain number of knots, at ſome diſtance from each other; each knot having its particular value, according as every merchant thinks proper. The marks are put, in order to know to whom each piece belongs; and the twiſts, to remember the prices.

The method of bleaching common linens, as it is practiſed in Anjou.—Immediately after the pieces are taken from the loom, they are carried to the whitſter, or bleacher, who puts them directly into wooden troughs, full of cold clear water; where with wooden mallets, which are moved by a water mill, they are ſo well agitated and beaten, that they are inſenſibly cleared from all their impurities.

Being taken out of the mill, they are ſpread on a meadow, where the dew which they receive during a week begins to bleach them.

Then they are put into a kind of wooden tubs, when they throw over them a common lye, quite hot.

The linens having thus gone through the lye, they take them out of the tub, to clean them again in the mill; then they ſpread them a ſecond time in the meadow, where they leave them a week, after which they give them a ſecond lye: all theſe ſeveral operations are repeated until the linens have acquired a perfect degree of whiteneſs. Then they fold them up, after a manner proper to each ſort, and to the places for which they are deſigned.

I do not find that any very conſiderable improvement in the whitening of ſilk and woollens has been lately made, excepting that it is aſſerted that ſilk may be cleared of its impurities to better advantage by the mild alkali of ſoda than by ſoap-lees, or ſoap; the former of which is apt to injure its texture, and the latter is expenſive. It is even ſaid that mere water will accompliſh the ſame, eſpecially if its vapour be confined, when heated in a veſſel, upon the principle of Papin's Digeſter. In all probability, however, a proceſs of this nature muſt require peculiar management; becauſe the water thus confined would doubtleſs be as active in diſſolving the ſilk itſelf, as cauſtic alkali might be. The remedy or precaution will conſiſt in ſuffering the ſteam to eſcape through an aperture, covered by a valve, loaded with no greater weight than experiment ſhall ſhew to be ſufficient for the intended purpoſe.

The dephlogiſticated or aërated marine acid, firſt diſcovered by Scheele, has ſince been applied to the art of bleaching linens and cottons. Several chemiſts of the firſt eminence have attended to the properties of this ſubſtance. Mr. Berthollet has given a deſcription of this method of bleaching in the ſecond volume of the Annals of Chemiſtry, of which I ſhall proceed to give an abridgment.

After mentioning the experiments of Scheele, in a general way, he proceeds to relate his own experiments and obſervations. The firſt object which this philoſopher propoſed, was to examine the ſolubility in water of the oxigenated muriatic acid gas, as he calls it, according to the New Nomenclature; becauſe he naturally imagined that, if he could obtain a ſolution ſomewhat concentrated, it would be much eaſier to make experiments with this liquor, than with the ſame ſubſtance in

the gaſeous form. He ſoon perceived that the gas was diſſolved in water more readily, and in a much larger quantity, than the carbonic acid gas, or fixed air; and that the water, upon ſaturation with it, acquired a very lively ſmell, a yellowiſh colour, and peculiar characters. Theſe firſt experiments were made by agitating the water in contact with this gas, in the ſame manner as that fluid is uſually impregnated with the carbonic acid gas; but the ſuffocating vapour which was emitted, led him to ſubſtitute the apparatus of Mr. Woulfe inſtead of that he had before uſed. Between the retort, and the bottles filled with water for the purpoſe of impregnation with this gas, he placed a ſmall bottle ſurrounded with ice, to retain the muriatic vapour which was not oxigenated. The bottles filled with water were likewiſe ſurrounded with ice. He obſerved, in this operation, that when the water became ſaturated with the gas, the gas itſelf aſſumed a concrete form, and was ſlowly precipitated to the bottom.

If a body with a recurved tube, fig. 15. C. be filled with this water, impregnated with the dephlogiſticated or oxigenated muriatic acid, and the outer extremity of the tube be immerſed under a receiver filled with water; if, in this ſituation, the fluid be expoſed to the light of the ſun, bubbles are ſoon diſengaged, which paſs into the receiver, and are found to conſiſt of pure or vital air. When the bubbles have ceaſed to be diſengaged, the liquor is found to have loſt its characteriſtic ſmell, colour, and all its diſtinctive properties; and is found to conſiſt of mere water, containing a proportion of common muriatic acid. This ſimple experiment, Mr. Berthollet obſerves, ought to be ſufficient to afford a conviction, that the oxigenated muriatic acid is really nothing but a combination of the muriatic acid with baſis of vital air, or oxigene, which is found ſo abundantly in the black oxide or calx of manganeſe, that nothing more is neceſſary than to urge this oxide by a ſtrong heat, in order to obtain a large quantity. Manganeſe, thus treated, is no longer proper to form the oxigenated muriatic acid; becauſe it is deprived of that portion of oxigene which is required to combine with part of the muriatic acid.

He remarks, that light poſſeſſes the property of diſengaging the oxigene which was combined with the muriatic acid, by reſtoring that elaſticity of which it was partly deprived; a reſtoration not to be effected by mere heat: he concludes therefore that the light combines with the oxigene, and that the elaſtic ſtate of vital air is owing to this combination; which air, by loſing a ſecond time its elaſticity in the proceſs of combuſtion, that is to ſay, by a rapid combination with ſome other body, again ſuffers the principle of light to eſcape, at the ſame time that much heat is diſengaged; the relation of which laſt ſubſtance with light is ſtill an object for future diſcovery.

If vegetable colours be plunged in the oxigenated muriatic acid, they diſappear more or leſs ſpeedily, and more or leſs perfectly. When the ſubſtance under examination poſſeſſes a mixture of different colouring parts, ſome diſappear more readily, and leave only thoſe which more effectually reſiſt the power of this agent, but have nevertheleſs ſuffered a conſiderable alteration. The yellow colouring matters uſually reſiſt the moſt ſtrongly, but at length they all diſappear; and when the oxigenated muriatic acid has exerted its whole action, it is found to be reduced to the ſtate of ordinary muriatic acid. Hence it follows, that the colouring matters have deprived it of the oxigene, or vital air; and have, by this combination, acquired new properties, at the ſame time that they have loſt that of producing colours. This ingenious chemiſt declines entering, in his preſent memoir, into the properties of theſe oxigenated ſubſtances; and proceeds to obſerve, that the oxigenated muriatic acid owes its property of deſtroying colours to the oxigene, which not only is com-

bined abundantly with it, but likewiſe adheres with very little force; and readily paſſes into a ſtate of combination with ſuch ſubſtances as have a certain degree of affinity with it. The habitudes of ſuch a variety of colouring matters as exiſt in nature, with the oxigene, with light, with alkalis, and with other chemical agents, cannot but form an highly intereſting, and almoſt entirely unexplored, part of natural philoſophy.

After having obſerved the action which the oxigenated muriatic acid exerciſes in general upon colouring matter, he concluded that it might produce the ſame effect upon thoſe ſubſtances which colour thread and linen, and which the art of bleaching propoſes to deſtroy. Without confining himſelf to deſcribe the proceſs as now practiſed, he enters into a conciſe detail of the imperfect eſſays he made at firſt; a detail which will be by no means without its utility to ſuch as are deſirous of carrying the proceſs into execution.

He at firſt uſed a very concentrated liquor, which he renewed when exhauſted, until the thread or cloth appeared ſufficiently white: but, in this way, he ſoon perceived that their texture was conſiderably weakened, and that they were even entirely deprived of their ſolidity. He therefore ſlightly diluted the liquor, and ſucceeded in bleaching his cloth, without altering it; but it ſoon became yellow by keeping, and more eſpecially when it was heated, or ſubjected to the action of an alkaline lixivium. He directed his reflections, therefore, to the circumſtances of the uſual proceſs of bleaching, which he endeavoured to imitate; becauſe he had adopted the opinion, that the oxigenated muriatic acid ought to act in the ſame manner as the expoſure of cloth upon bleach-grounds; which expoſure alone is not ſufficient for the purpoſe, but appears merely to diſpoſe the colouring matter to ſolution in the alkali of lixiviums. He examined the dew which is precipitated from the atmoſphere, and likewiſe that which is afforded by the nocturnal tranſpiration of plants; and obſerved that both the one and the other were ſaturated with oxigene to ſuch a degree, as to deſtroy the colour of paper weakly tinged with turnſole; and he remarks that the ancient prejudices reſpecting May dew, which is the ſeaſon wherein the tranſpiration of plants is abundant, might probably depend on ſome obſervation of this nature.

He therefore employed, alternately, the lixiviums, and the action of the oxigenated muriatic acid; by which means he obtained a permanent white. And as it is the practice, in the ordinary way of bleaching, to paſs the cloth through ſour milk, or vitriolic acid diluted with a large quantity of water, he made the trial likewiſe of paſſing his cloths through a very dilated ſolution of vitriolic acid, and obſerved that the white was much brighter.

As ſoon as he had made uſe of the intermediate lixiviums, he found that it was not neceſſary to uſe a concentrated liquor, or to leave the cloth long in the fluid at each immerſion. By this obſervation he avoided two inconveniences, which might have rendered the proceſs impracticable in the large way: the firſt is, the ſuffocating ſmell of the fluid, which would be very incommodious, and even highly dangerous to be reſpired for a long time, and which has diſcouraged ſeveral operators from purſuing their attempts in this way; the ſecond is, the danger of weakening the cloth. At this period of his experiments he likewiſe gave up the idea of mixing alkali with the oxigenated muriatic acid, as he had before done in moſt of his experiments *.

This was the ſtate of the experiments of this excellent chemiſt, when he repeated

* Journal de Phyſique, 1785.

them

them in the preſence of the celebrated Mr. Watt. A ſingle glance, he obſerves, is ſufficient to a philoſopher whoſe abilities had been ſo long exerciſed upon the arts. Mr. Watt ſoon afterwards wrote to him from England, that in his firſt operation he had bleached five hundred pieces of cloth on the premiſſes of Mr. Grigor, who has large bleach-grounds at Glaſgow, and continues to uſe this new proceſs.

In the mean time Mr. Bonjour, who had aſſiſted Mr. Berthollet in his experiments, and who to a large ſhare of ſagacity has added a very extenſive knowledge in chemiſtry, entered into an agreement with Mr. Conſtant of Valenciennes to form an eſtabliſhment in that town. This project was oppoſed by the prejudices and intereſt of the bleachers, who were apprehenſive of the competition of a new method. Mr. Conſtant could not even procure a piece of ground in the town of Valenciennes: but the Count de Belainge favoured this enterpriſe, and gave up a piece of ground which poſſeſſed every advantage; but, being at a certain diſtance from Valenciennes, would have the diſadvantage of diſtance, if any manufactory ſhould be eſtabliſhed at Valenciennes itſelf. Mr. Bonjour had given up the well-grounded hopes which his knowledge and talents gave him reaſon to expect at Paris; and had in return found, in the enterpriſe to which he had devoted his attention, nothing but thoſe diſguſting circumſtances which uſually accompany new proceſſes in the arts. He addreſſed himſelf to the Bureau de Commerce, not to reward his ſervices, but to requeſt that he might be defended from the diſadvantages and obſtacles which prejudice and an oppoſition of intereſt had created in Valenciennes, by granting to him a certain ſpace of two leagues round Valenciennes and Cambray, in which he alone might, during a certain number of years, exerciſe this new art; without conſtraining in any reſpect thoſe who might chuſe to adhere to the ancient proceſſes, or attempt new proceſſes, in which no uſe ſhould be made of the oxigenated muriatic acid. He offered to inſtruct in his manufactory, in all the details of his proceſs, all ſuch as might be deſirous of uſing it, and might obtain the ſanction of the miniſtry. It is probable that, if his requeſt had been granted, the eſtabliſhment at Valenciennes might have produced a greater degree of confidence in thoſe who had undertaken to make the neceſſary advances. It is probable, continues Mr. Berthollet, that they might have ſhortened their trials, inſtead of eſtabliſhing the proceſs at Courtray, as they have done; many artiſts might probably have been formed under the direction of Mr. Bonjour; and a great number of eſtabliſhments might have been formed in the French provinces, by avoiding thoſe fruitleſs trials which tend to throw diſcredit upon an uſeful art.

As ſoon as Mr. Berthollet had reaſon to hope that the proceſs might be executed in the large way, he endeavoured to diminiſh the price of the liquor, by decompoſing the marine ſalt in the very operation which ſerved to form it. His firſt trials were unſucceſsful; but Mr. Welter, a young and ingenious chemiſt to whom Mr. Berthollet had entruſted the management of the proceſs, obſerved that it might be of advantage to dilute the vitriolic acid; and the operation then ſucceeded in the moſt ſatisfactory manner. He immediately wrote to Mr. Bonjour and Mr. Watt, the latter of whom informed him that he had made this change from the firſt; and the operation was long afterwards deſcribed by Mr. Chaptal, in a Memoir forwarded by him to the Academy of Sciences. Mr. Watt had likewiſe made uſe of a certain caſk or butt, of a conſtruction which Mr. Berthollet was not acquainted with; but, before this apparatus was mentioned, Mr.

Welter had conſtructed one, which is not only very proper to prepare the oxigenated muriatic acid, but very well calculated for ſeveral other chemical operations.

The intention of this apparatus is to multiply the ſurfaces of contact between the gas and the water, as it is evident that the combination can take place only at their ſurfaces. That part of the gas which did not enter into combination in the lower ſpace, where it is firſt conveyed, paſſes into a ſecond cavity or ſpace which is above the tube intended to give it vent. The veſſel which is intermediate between the pneumatic caſk and the diſtillatory mattraſs, is deſigned to retain that part of the muriatic acid which is not oxigenated: a ſmall quantity of water is put into this veſſel, a glaſs tube being plunged therein, the height of which exceeds that of the column of water the gas muſt overcome in the caſk. The gas which paſſes out of the mattraſs compreſſes the water in the intermediate veſſel with a force equal to that oppoſed to its diſengagement; ſo that the water riſes in the tube of ſafety, and forms a column equal to the weight of the water which preſſes on the tube through which the gas enters the caſk. But if, during the operation, a ſudden cooling or rapid abſorption of gas ſhould take place, the water deſcends again in the tube, the air of the atmoſphere enters, and prevents a vacuum from being formed within, which would have been attended with a reſorption of the liquor, and conſequently break the diſtilling veſſel by the ſudden cooling. This tube of ſafety, which is likewiſe due to the ingenious Mr. Welter *, is equally applicable to other pneumatic diſtillations.

If the oxide or calx of manganeſe be of a good kind, in ſmall cryſtals, and contain very little foreign matter, the proportions which Mr. Berthollet found beſt calculated for diſtillation, are the following:

Six ounces of pulverized calx of manganeſe, one pound of pulverized ſea ſalt, twelve ounces of concentrated vitriolic acid, and from eight to twelve ounces of water. If the calx of manganeſe contain foreign earth or metallic ſubſtances, the quantity muſt be augmented in proportion to its impurity. It will be known, after the operation, whether a ſufficient quantity has been employed; becauſe a ſmall quantity ought to remain undecompoſed, and of its original black colour: from this obſervation, the quantity proper to be uſed in the following operations may be aſcertained.

When the calx of manganeſe is found to contain calcareous ſpar, as may be known by its effervеſcing upon the contact of a ſmall quantity of vitriolic acid, it is proper to waſh it before the operation with diluted vitriolic acid, to ſeparate the calcareous part, which might be troubleſome on account of the effervеſcence it produces: the calx muſt be dried after this waſhing.

Mr. Berthollet is of opinion, from his trials, that when the calx of manganeſe contains much phlogiſticated air, it is ſcarcely proper to form the oxigenated muriatic acid: Mr. Fourcroy however aſſerts, that the phlogiſticated air eſcapes in diſtillation from manganeſe by a degree of heat leſs than ignition, but that ignition is neceſſary to deprive it of its vital air. It might perhaps be found advantageous to make uſe of this information to purify ſuch manganeſe as contains phlogiſticated air, by diſtilling off this laſt aërial ſubſtance by a moderate heat before it is applied to the purpoſe of oxigenating the marine acid.

A greater or leſs quantity of water muſt be added, not only according to the

* Likewiſe thought of by the celebrated Chaptal.—See his Elements of Chemiſtry.

degree

degree of the concentration of the ſulphuric acid, but likewiſe according to the quantity of matter ſubjected to diſtillation. If this quantity be conſiderable, the acid muſt be more diluted than if it be ſmall. It might be more advantageous to make uſe of an acid which had not been concentrated; becauſe the operation of concentrating it adds to its price, and it is obliged to be again diluted with water. But Mr. Berthollet obſerves, that this ſaving can only take place when the manufactory of the vitriolic acid is near at hand; for in thoſe ſituations where this acid is to be brought from a conſiderable diſtance, the expence of carriage of a greater quantity of fluid might exceed that of concentrating it.

When the materials are prepared, the calx of manganeſe muſt be carefully mixed with the ſea ſalt, and the mixture introduced into the diſtillatory veſſel, placed on a ſand bath: the vitriolic acid muſt then be diluted, and ſuffered to cool; after which it is to be poured on the mixture, and the tube of communication between the mattraſs and the intermediate veſſel quickly fitted in. A particular attention to the lutings is required in this operation. Mr. Chaptal takes notice, that when the vapour is perceived to eſcape by the ſmell, it is ſometimes difficult to aſcertain the imperfect place; but that if a feather dipped in volatile alkali be paſſed on ſuch occaſions over the lutes, it will ſhew the faulty place, by the white cloud of ammoniac formed in conſequence of the combination of marine acid with the volatile alkali.

The ſize of the veſſels ought to be ſuch, that the mattraſs ſhould be about one-third empty; and that, for the quantity here laid down, the caſks ſhould contain one hundred pints of water, with an empty ſpace of the bulk of about ten pints; becauſe, when the gas comes to occupy the cavities deſigned to receive it, the water will require a ſpace into which it may aſcend.

Before the operation is begun, the pneumatic caſk muſt be filled. The mixture being made, the gas, which ſoon begins to be diſengaged, firſt drives the atmoſpheric air out of the apparatus. As ſoon as it is apprehended that the atmoſpheric air has paſſed into the cavities, it is emptied out by means of a recurved tube, ſucceſſively introduced beneath each; and in order to drive the water out which has entered into the tube, Mr. Berthollet recommends blowing ſtrongly into it. The operation is ſuffered to go on without the application of heat, until it is perceived that the bubbles are more ſlowly emitted: at this period, a ſlight degree of heat is applied. It muſt not be ſtrongly urged at the beginning; but by a gradual increaſe it is at laſt to be carried to ebullition, towards the end of the operation. It may be known when the operation is near its termination, by the tube of communication and intermediate veſſel becoming hot.

When the gas is no longer diſengaged but in ſmall quantities, the fire is to be put out, and a ſufficient time muſt be ſuffered to elapſe until the mattraſs is nearly cold. The tube of communication may then be removed, and hot water poured in to keep the matter in ſolution, that it may be more eaſily taken out: this reſidue is to be poured into a large veſſel, intended to preſerve it for a uſe to be preſently mentioned. The operation laſts longer in proportion to the quantity of matter. With the before-mentioned quantity, it ought to laſt five or ſix hours. It is proper not to be too much in haſte, becauſe a larger quantity of gas is by that means obtained. One ſingle perſon may inſpect and manage ſeveral of theſe apparatus, and the quantities may be much larger.

The intermediate veſſel gradually becomes filled with a fluid, which conſiſts of pure but weak muriatic acid: ſeveral operations may however be made without taking it out; but when it is apprehended that there is not a ſufficient ſpace left

empty,

empty, this acid is taken out by means of a ſyphon: and, when its quantity is conſiderable enough, it may be ſubſtituted inſtead of the mixture of ſulphuric acid and muriate of ſoda, in a ſimilar operation, if it be not wanted for another uſe. In order that the quantity of common muriatic acid which paſſes out of the mattraſs, may be inconſiderable, it is expedient that the firſt tube ſhould make a right angle, or even a more obtuſe angle, with the body of the mattraſs. During the operation, it is neceſſary to ſtir the water, from time to time, by means of the agitator, in the apparatus, to favour the abſorption of the gas by the water. When this is completed, the liquor is ſufficiently ſtrong to be uſed in bleaching. A ſmaller proportion of water may be put into the caſk, and the fluid may afterwards be properly diluted.

In this ſtate of concentration, though the liquor retains a conſiderably ſtrong ſmell, yet it cannot prove noxious, or even very inconvenient, to thoſe who uſe it. It is nevertheleſs proper to conduct it into the veſſels in which the cloths are arranged by wooden channels, fitted to the opening at the lower part of the caſk. It is proper to draw off the liquor from the caſk as ſoon as it is prepared, becauſe it acts upon the wood, and not only becomes by that means weaker, but likewiſe haſtens the deſtruction of the caſk: but when it is conveyed into a veſſel in which cloths are properly placed, theſe ſpeedily weaken it to ſuch a degree that it does not perceptibly act upon the wood.

The cloths are to be prepared by leaving them twenty-four hours in water, or ſtill better in the old lixivium, to extract the dreſſing; after which they muſt be once or twice well waſhed in alkaline lixiviums, becauſe all that part which can be extracted by the lixiviums would have neutralized a portion of the liquor, which requires to be carefully uſed. After this the cloth muſt be carefully waſhed, and diſpoſed upon ſticks in ſuch a manner that it may be impregnated with the liquor poured on it, without any part being compreſſed. The framing of the ſticks, as well as the caſk and veſſel intended to contain the cloths, ought to be conſtructed without iron; becauſe this metal becomes calcined by the oxigenated muriatic acid, and would produce iron-moulds, not to be taken out but by means of ſalt of ſorrel.

The firſt immerſion muſt be longer than the following ones; it may laſt three hours: after which, the cloth is to be taken out, lixiviated anew, and then put into a ſhallow veſſel, in order that new liquor may be poured on it. It is ſufficient that this immerſion, and the following, ſhould continue for the ſpace of half an hour. The cloth is taken out, and cleared of the liquor by preſſure; then lixiviated, and ſubjected to new immerſions. The ſame liquor may be uſed until it is exhauſted; and when it is found to be much weakened, a proportion of the liquor which has not been uſed may be added.

When the cloth appears white, excepting at the ſelvidges, and a few threads darker than the reſt, it muſt be impregnated with black ſoap, and ſtrongly rubbed; after which it is to be lixiviated for the laſt time, and immerſed once more in the liquor.

The number of lixiviations and immerſions which are neceſſary, cannot be determined, becauſe it varies according to the nature of the cloth: the limits of this number, however, are between four and eight, for linen and hempen cloths. Mr. Berthollet expreſſes his inability to point out the beſt method of making the alkaline lixiviums; this uſeful art being ſtill a matter of mere practice, and variouſly performed in different places. It appeared advantageous to him to render the alkali cauſtic, by mixing one third of lime; but in this caſe care muſt be

taken that the lixivium be ſtrained through a cloth, in order that the calcareous earth may not mix itſelf with the linen, as its particles might corrode or wear it by their hardneſs. By this management the lixivium being rendered more active, does not require ſo large a quantity of alkali; and nevertheleſs, if the quantity of alkali be not too conſiderable, it produces no damage to the cloth, notwithſtanding the contrary prejudice, which is very general. He has likewiſe remarked that it was of no advantage, and even prejudicial, that the lixiviations ſhould be of long duration; but it is neceſſary that the fluid be very hot, and of conſiderable ſtrength, otherwiſe the cloths bleached by the aërated marine acid would become coloured and ruddy when ſubmitted to new lixiviations. This accident took place in the trials already mentioned. Cottons are much more eaſily and ſpeedily bleached than linens: two lixiviums, or at moſt three, with the ſame number of immerſions in the liquid, are ſufficient; and as they are ſo much the more readily bleached, it is advantageous, when linen, hemp, and cotton are to be bleached, to reſerve the liquors for the latter which have been already weakened by exerting their action on the former. Such liquors as are ſo exhauſted as ſcarcely to act upon hemp or linen, will do very well for cotton.

After the laſt immerſion in the liquor, the cloth muſt be plunged in ſour milk, or water acidulated with vitriolic acid. The true proportion is not well aſcertained; but our author thinks, from his experiments, that one part of the acid by weight, with fifty parts of water, may be employed ſucceſsfully, and without danger. The cloths are to be kept about half an hour in this fluid, warmed; after which, they muſt be ſtrongly preſſed, or wrung, and immediately plunged in common water: for, if they were ſuffered to dry by evaporation, the vitriolic acid, becoming concentrated, would attack them. When the cloths are well waſhed, nothing more is neceſſary than to dry and prepare them in the uſual manner.

It is an obvious precaution, that this acid water be not too ſtrong, as it would of courſe injure the texture of the ſtuffs.

Fig. 1. Pl. II. exhibits the apparatus for preparing the liquid intended to be uſed in this new method of bleaching. A B C is a furnace; c is the mattraſs, or diſtillatory veſſel; G H I the tube of communication with K, the intermediate veſſel; L the tube of ſafety; M a tube communicating with the tub N, the ſection of which tub is exhibited in fig. 2, while the lower orifice of this tube is ſeen at y. In the tub N are fixed three inverted veſſels, open beneath, as repreſented in fig. 3, and intended to contain the aëriform marine acid. P P P are agitators for the purpoſe of ſtirring the water by the rotation of the upright poſt O Q. The effect of this apparatus may be eaſily underſtood, by conſidering that the aeriform dephlogiſticated marine acid, iſſuing from the tube y, paſſes into the veſſel X, until it has excluded the water it may contain: after which the ſurplus iſſues through the tube Z, and runs into the ſecond veſſel; which, becoming alſo filled, affords its ſurplus to the third, or uppermoſt veſſel. Hence it follows, that three ſurfaces of the water are expoſed to an atmoſphere of dephlogiſticated marine acid; and theſe ſurfaces muſt of courſe be changed by the rotation of the agitators. In this manner the water becomes impregnated, and may be drawn off at P. It is of conſequence to aſcertain its relative ſtrength, in order that the experiments may at all times be equally ſucceſsful. Mr. de Croiſille makes uſe of a ſolution of indigo in the vitriolic acid; for which purpoſe he takes one part of finely-pulverized indigo, with eight parts of concentrated vitriolic acid. This mixture is kept in a mattraſs for ſeveral hours on the water bath; and, when the ſolution is complete, it is diluted with a thouſand parts of water. In order to aſcertain the force of the

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oxigenated muriatic acid, one meaſure of this ſolution is put into a graduated tube of glaſs, and the liquor or impregnated water is added, until the colour of the indigo is completely deſtroyed. In this way it is aſcertained, by means of the graduations, how many meaſures of any liquor, whoſe goodneſs has been aſcertained by direct experiments upon linen or cotton, are neceſſary to deſtroy the colour of one meaſure of the ſolution of indigo; and this number will ſerve to aſcertain the reſpective force of all the liquors which are required to be compared together. Mr. Watt makes uſe of a ſolution of cochineal for the ſame purpoſe.

In the ſixth volume of the Annals of Chemiſtry, Mr. Berthollet has publiſhed ſome additions to the foregoing Memoir, which, on account of its extenſive utility, I have ſcarcely at all ſhortened. They are the following:—Mr. Welter finds that it is advantageous to terminate the proceſs by expoſing the thread or cloth for three or four days in the field; during which they muſt be occaſionally watered, and afterwards waſhed with pure water. He conſiders this expoſition as indiſpenſable. But Mr. Berthollet obſerves, that other perſons have bleached to the perfect ſatisfaction of artiſts without it; though he admits that it may happen, in the large way, that certain pieces may not turn out perfectly white after the laſt operation, in conſequence of ſome of their parts having ſuffered caſual preſſure; and he thinks that, although a continuance of the operation would remove theſe imperfections, it might, in ſuch caſes, prove more advantageous to remove them by expoſure on the graſs; very little loſs of time, and no conſiderable extent of premiſes, being required for this purpoſe.

Mr. de Croiſille has excluded the uſe of wood in every part of his apparatus; and has applied the proceſs not only to bleaching, but to the diſcharging of colours in dyed cottons or linens.

Mr. Berthollet further obſerves, that the precaution of plunging the cottons in pure water, after they have been taken out of the acidulated water, is not ſufficient; but it is neceſſary to plunge them into a weak cauſtic lixivium, moderately heated, and keep them there for a ſhort time.

When the liquor is ſuffered to run immediately into the troughs, care muſt be taken to mix it well with the agitator; becauſe otherwiſe the moſt ſaturated liquor, which occupies the lower part of the veſſel, running firſt, would exert too ſtrong an action; or if half or three quarters of the liquor be drawn off, and mixed with the proper quantity of water, according to the precautions before eſtabliſhed, the reſt of the fluid may be uſed together with the water for the ſucceeding operation: laſtly, he obſerves that this proceſs, ſimple as it is, can ſcarcely be carried into execution, without, in the firſt inſtances, being directed by a perſon to whom the operations of chemiſtry are familiar. He obſerves that a diminution, or even an equality of the expences, relative to the ordinary proceſs, is not to be hoped for, excepting for the bleaching of fine cloths, unleſs the operator poſſeſſes a good proceſs to extract the ſoda from the reſidue of the diſtillation; and without this condition the bleaching of coarſer cloths ought not to be undertaken, excepting in thoſe caſes wherein the advantages ariſing from the ſpeed of the operation, the facility of performing it in all places and at all times, and the diminution of the ſtock or capital, are ſufficient to compenſate for the exceſs of the price. Theſe obſervations are perhaps applicable to linens, and not cottons. It is not poſſible, he continues to obſerve, to lay down principles applicable to every particular caſe; but he adviſes thoſe who may undertake this object, to begin by trials, and by means of thoſe trials to form calculations, without any allowance on the favourable ſide. On the other hand, he adviſes the operator not to ſuffer himſelf to be

impoſed on by thoſe loſſes which ariſe for want of being familiarized with the operations; as there is no great expence incurred by making trials for a time, by which this advantage is derived, that the operator renders himſelf more expert for carrying more extenſive proceſſes into effect.

BLENDE. An ore of zinc, likewiſe known by the name of Mock Lead, Falſe Galena, or Black Jack. There are ſeveral varieties of this ore. In general, they contain about half their weight of zinc, about one fourth ſulphur, and the reſt iron, copper, lead, and ſome earth in varied proportions.

BLOOD. The fluid which firſt preſents itſelf to obſervation when the parts of living animals are divided or deſtroyed, is the blood, which circulates with conſiderable velocity through veſſels, called Veins and Arteries, diſtributed into every part of the ſyſtem. It can ſcarcely admit of doubt, that the component parts, or immediate principles, of the blood muſt differ in the various and exceedingly diſſimilar genera and ſpecies of animals which occupy the land and waters of the globe; and that there are likewiſe differences in the ſtate or compoſition of this fluid in the ſame animal according to its ſtate of health, as well as the ſituation of the veſſels from which it may be extracted. Theſe differences can be aſcertained only by the united efforts of the anatomiſt and the chemiſt. But as the difficulty and extent of the ſubject have hitherto prevented any conſiderable progreſs, it becomes an object of neceſſity to confine our attention to the blood of man, or of ſuch quadrupeds as afford this fluid in a ſtate not obviouſly different from that of the human ſpecies.

Recent blood is uniformly fluid, and of a ſaline or ſlightly ferruginous taſte. Under the microſcope, it appears to be compoſed of a prodigious number of red globules, ſwimming in a tranſparent fluid. After ſtanding for a ſhort time, its parts ſeparate into a thick red matter, or craſſamentum, and a fluid called Serum. If it be agitated till cold, it continues fluid; but a conſiſtent polypous matter adheres to the ſtirrer, which by repeated ablutions with water becomes white, and has a fibrous appearance: the craſſamentum becomes white and fibrous by the ſame treatment. If blood be received from the vein in warm water, a ſimilar filamentous matter ſubſides, while the other parts are diſſolved. Alkalis prevent the blood from coagulating; acids, on the contrary, accelerate that effect. In the latter caſe, the fluid is found to contain neutral ſalts, conſiſting of the acid itſelf, united with mineral alkali, which conſequently muſt exiſt in the blood, probably in a diſengaged ſtate. Ardent ſpirit coagulates blood. On the water bath, blood affords an aqueous fluid, neither acid nor alkaline, but of a faint ſmell, and eaſily becoming putrid. A ſtronger heat gradually dries it, and at the ſame time reduces it to a maſs of about one-eighth of its original weight. In this ſtate it ſlightly attracts the humidity of the air, and effervеſces with acids; but by a longer expoſure for ſome months it becomes covered with an efflorеſcence of mild mineral alkali. By deſtructive diſtillation, this animal fluid affords a watery liquor, holding in ſolution a neutral ſalt with exceſs of volatile alkali, but whoſe acid part has not been well aſcertained: next follow a light oil, a denſe coloured oil, and foul or oleaginous volatile alkali. The reſidue is a coal of a very different incineration, containing common ſalt, mineral alkali, and an earth, which is probably a combination of lime and phoſphoric acid.

The ſerum of blood exhibits marks of a diſengaged alkaline ſalt, and is greatly diſpoſed to putrefy. It unites with water in all proportions, and forms a milky fluid, which may be coagulated by acids, or ardent ſpirit. An increaſe of temperature cauſes ſerum to become conſiſtent, with little or no loſs of weight, in the ſame manner as

the white of egg; and it is accordingly uſed for the ſame purpoſe in clarifying liquids. From a variety of experiments, it appears highly probable that white of egg, ſerum of blood, and the pure curd of milk do not eſſentially differ from each other: and to theſe we may perhaps add the vegetable gluten, which conſiderably reſembles cheeſe.

Alkalis render the ſerum of blood more fluid: acids coagulate it, and exhibit the neutral ſalt they would have produced by combination with mineral alkali. The coagulum affords, by diſtillation, phlegm, mild volatile alkali, and a thick fetid oil; and the reſidue affords mild mineral alkali. Theſe products are the ſame as are afforded by the ſerum itſelf.

Serum is coagulated by ardent ſpirit, merely by the loſs of part of its water. When rendered concrete by heat, and expoſed to the action of nitrous acid, it affords phlogiſticated air by a ſlight heat, which is followed by nitrous air; and the reſidue affords acid of ſugar, together with a ſmall portion of acid of apples.

The craſſamentum of blood, when treated in the way of deſtructive diſtillation, becomes dry and brittle, at the ſame time that it emits an alkaline phlegm: this is followed by an empyreumatic ſtinking oil, and concrete volatile alkali. A ſpungy brilliant coal remains, which by treatment with vitriolic acid is found to contain mineral alkali and iron, as appears by the production of Glauber's ſalt and martial vitriol: coaly matter and phoſphorated lime are then left behind.

The fibrous matter which is obtained by waſhing the red part of the blood, reſembles the ſerum in many of its properties; though it differs from it in not being ſoluble in water, in becoming hard by a very gentle heat, and in not combining with alkalis. Acids unite with it, and in particular the nitrous acid diſſolves it, and extricates phlogiſticated and nitrous air; while the reſidue, by evaporation, affords acid of ſugar in cryſtals, a peculiar oil in flocks, and the phoſphoric ſalt of lime. Its volatile products, by deſtructive diſtillation, are nearly the ſame as thoſe of ſerum: but its reſidue contains no ſalt, except the combination of lime and phoſphoric acid; the other ſalts it might have contained having probably been carried off during the waſhing. Marine acid forms a green jelly with the fibrous part of the blood.

Blood contains much iron. The experiments of Menghini, Bucquet, and Lorry prove that the metal is capable of paſſing into the blood by the firſt paſſages, ſince patients who are under a courſe of martial medicine void it by the way of urine. When the coagulated part of the blood has been waſhed, if that part which has retained the colouring matter be burned, and the coal be lixiviated, the reſidue of this lixivium is in the ſtate of ſaffron of Mars, of a fine colour, and uſually obedient to the magnet.

The colour of blood has been attributed to this iron; and it is very true that the colour appears to be entirely formed of it; for there exiſts no veſtige of this metal in the waſhed and diſcoloured coagulum: but as, on the other hand, the blood does not become coloured without the concourſe of air, and as vital air alone is abſorbed in reſpiration, it appears that the colour is owing to iron calcined by the pure air, and reduced to the ſtate of red calx.

BLOW-PIPE. This uſeful inſtrument has been already deſcribed under the article APPARATUS, which ſee. The preſent article will therefore conſiſt of an account of the materials, or ſubjects, upon which experiments are made with this inſtrument. The bodies intended to be heated by the blow-pipe muſt not in general exceed the ſize of a pepper-corn, unleſs bellows and very large flame be uſed. The proper ſupports are either a piece of ſmooth cloſe-grained charcoal, for ſuch

bodies

bodies as are not ſubject to ſuch an alteration of their properties, from the inflammability of the coal, as might be contrary to the nature of the inveſtigation. This ſupport is therefore moſt frequently uſed; as it is properly adapted for ſaline, earthy, and many metallic bodies. The other ſupport conſiſts of a ſpoon, ſomewhat leſs than a quarter of an inch in diameter, made of a metal not ſubject to calcination; that is to ſay, pure gold, ſilver, or platina, or ſuch a mixture of theſe metals as might be found to be leaſt deficient in the requiſite degree of hardneſs, which gold or ſilver alone does not poſſeſs. Bergmann adviſed to add one-tenth of platina to a given maſs of ſilver. I find, however, that this mixture, with picked grains of crude platina, forms a compound harder indeed than pure ſilver, but ſubject to bliſter at a low red heat, and perhaps more fuſible than ſilver itſelf. There is, however, no very conſiderable inconvenience reſulting from the uſe of a ſmall ſpoon, either of gold, or of ſilver; and platina, purified to ſuch a degree as to be perfectly malleable, and to exceed 21,0 in ſpecific gravity, poſſeſſes every quality which can be wiſhed for. The ſmall metallic ſpoon muſt of courſe be properly fixed in a ſocket of metal, provided with a wooden handle.

Very ſmall or pulverulent ſubſtances are apt to be carried away by the current of flame. Theſe may be ſecured by making a ſmall hole in the charcoal, in which the powder is to be put, and covered with another ſmall piece of charcoal, which partly protects them from the flame. Some experiments of reduction are made by binding two ſmall pieces of charcoal together, cut in a channel along the piece intended to be the undermoſt, and making a cavity in the middle of this channel to contain the ſubject matter of examination. With this apparatus the flame is urged through the channel between the two pieces of coal, and violently heats the ſubſtance in the cavity, which may be conſidered as a cloſed veſſel.

A great number of mineral bodies are not fuſible by mere flame, urged by common air through the blow-pipe; though dephlogiſticated or vital air ſubdues moſt bodies.

Whenever therefore the fuſion of any refractory ſubſtance is to be attempted, ſome other ſubſtance muſt be added which is more fuſible, and capable of diſſolving the former. Theſe ſolvents in the dry way are diſtinguiſhed by the name of Fluxes, and, like the ſolvents uſed in the humid way, are moſtly ſaline. It may eaſily be imagined, that the nature of the products will greatly vary, according to that of the flux which enters into combination with them; and accordingly they are varied in experiments, as well as in operations in the large way. The blow-pipe experiments, though conducted upon the ſame principles as thoſe upon a larger ſcale, differ nevertheleſs from them in two particulars; namely, that the whole of the phenomena are viſible throughout, and that the reſidues are of no value, otherwiſe than as they ſerve to indicate facts. For theſe reaſons, every flux without exception might be uſed with the blow-pipe, provided it were not of ſuch a nature as to ſink into the charcoal. We may therefore ſelect a certain ſmall number of the moſt convenient fluxes, and note the effects which they reſpectively produce upon the various mineral bodies; and theſe will ſerve as indications to enable the chemical enquirer to diſtinguiſh them again with a much greater degree of accuracy than by their external figures, not to mention that he may alſo derive the greateſt advantage with regard to the more extenſive operations he might be diſpoſed to undertake. A conſiderable part of this preliminary labour has already been performed by Engeſtrom, Bergmann, Mongez, and others; and it is now become uſual for chemiſts, among their other experiments on minerals, to mention their

habitudes with the blow-pipe. In the following general ſketch, I ſhall chiefly recur to Bergmann's Treatiſe on the Blow-pipe, of which we have an Engliſh tranſlation in the ſecond volume of his Eſſays. A good Treatiſe on this ſubject by Engeſtrom may likewiſe be conſulted at the end of the Engliſh edition of Cronſtedt's Mineralogy; and the habitudes of a very great number of bodies with the blow-pipe may be ſeen in the French edition of Bergmann's Sciagraphia Regni Mineralis, by the abbé Mongez, under the title of Manuel du Minéralogiſte.

The fluxes which have obtained the general ſanction of chemiſts, on account of the extenſive uſe they have been applied to by Bergmann, are:

1. The phoſphoric acid, or rather the microcoſmic ſalt, as it is generally called, which contains that acid, partly ſaturated with mineral, partly with volatile alkali, and loaded beſides with much water and a gelatinous fat. This ſalt, when expoſed to the flame, boils and foams violently with a continual crackling noiſe, until the water and volatile alkali have flown off: afterwards it is leſs agitated, ſending forth ſomewhat like black ſcoriæ, ariſing from the burned gelatinous part: theſe are ſoon diſpelled, and exhibit a pellucid ſphærule, encompaſſed by a beautiful green cloud, which is occaſioned by the deflagration of the phoſphorus ariſing from the extrication of the acid by means of the inflammable matter.

The clear globule which remains upon the removal of the flame, continues longer ſoft than that formed by borax, and therefore is more fit for the addition of the matter to be diſſolved. The volatile alkali is expelled by the fire, and leaves an exceſs of acid, which eaſily attracts moiſture in a cool place.

2. The mineral alkali, or ſal ſodæ, which, when fuſed upon charcoal, melts ſuperficially with a crackling noiſe, penetrates the charcoal, and diſappears. This, in the ſpoon, yields a permanent ſphærule, ſo long as it is kept fluid by the blue apex of the flame; but when the heat is diminiſhed, it aſſumes a milky opacity, and cannot be employed upon charcoal. This alkali attacks ſeveral ſubſtances, particularly ſiliceous matters.

3. Cryſtallized borax, expoſed to the flame upon charcoal, at firſt becomes opake, white, and wonderfully intumeſcent; it throws out branches and various protuberances: but when the water is expelled, it is eaſily collected into a maſs, which, when well fuſed, yields a colourleſs ſphærule, and retains its tranſparency even after cooling: if calcined borax be employed, the clear ſphærule is more ſpeedily obtained. This ſalt conſiſts of a mineral alkali, partially ſaturated with a peculiar acid, known by the name of Sedative Salt; each of its principles is ſeparately fuſible, and each diſſolves a great number of other matters.

The habits of theſe ſalts, when expoſed to fire, being once known, it will be eaſy to underſtand the differences occaſioned by the different additions.

The habitudes of the ſalts, according to Bergmann, are as follows:

The acid of arſenic in the dry ſtate, when urged by the blow-pipe upon charcoal, becomes ſo far reduced as to regenerate white arſenic, and emit the ſmell of garlic. In the ſpoon it fuſes, and does not ſmoke, unleſs by a partial reduction from the flame, or the metallic ſupport.

The acid of molybdena, when expoſed to the flame upon charcoal, is abſorbed.

Alkalis. The cryſtallized vegetable alkali firſt becomes opake, and decrepitates long and violently, then melts into a globule, which perſiſts in the ſpoon, but expands on the charcoal, and is abſorbed with a crackling noiſe.

The mineral alkali has the ſame properties as the ſal ſodæ, already deſcribed.

The volatile alkali liquefies a little, and is diſſipated.

Neutral Salts. Several of the neutral ſalts flow twice; but, according to their different

different natures, they exhibit different phenomena, which a few examples will ſufficiently illuſtrate.

The Decrepitating Salts. Theſe are broken and diſperſed by ſudden heat: of this ſort are vitriolated vegetable and volatile alkali, ſalited vegetable and mineral alkali.

Volatile Salts, which have a baſe totally volatile, and generally fly off; vitriolated, nitrated, and ſalited volatile alkali.

Genuine Salt of Amber, by the exterior flame on the charcoal, liquefies and ſmokes; by the interior takes fire, and in burning diſappears with a blue flame.

In the ſpoon the ſame happens, except when the ſalt abounds with oil, which almoſt always happens; in this caſe, ſome coaly veſtiges remain. The ſpurious ſalt of amber differs according to the frauds uſed in its preparation; it generally, in the beginning, ſwells, ſmokes, and grows black, then white, and finally melts into a fixed white maſs.

Detonating Salts. Theſe ſalts, which always abound with nitrous acid, liquefy in the ſpoon, and perſiſt even on the charcoal, unleſs it takes fire; for when ignited, they immediately take fire on the contact of phlogiſton, ſending forth a violent flame with a detonating noiſe. During this operation, the acid is diſſipated, and the baſis, if fixed, remains alone. If the baſe be volatile, ſcarce any detonation is excited; for the ſalt flies totally off.

Nitrated vegetable alkali ſhews a blue flame; but the nitrated mineral and volatile alkali, a yellow one.

Carbonaceous Salts. Theſe, by the combuſtion of their acid, yield ſpongy coals, which when ignited ſoon grow white, leaving behind the alkaline baſe: ſuch are, acid of tartar, crude tartar, ſal acetoſellæ, and tartarized vegetable and mineral alkali.

Hepatiſcent Salts. Theſe, expoſed to the flame on the charcoal, flow, and yield a yellow or red maſs, which diffuſes an hepatic ſmell, eſpecially when moiſtened by any acid. To this claſs belong all thoſe fixed in the fire, containing vitriolic acid, which, when ſaturated with the phlogiſton of the charcoal, generate ſulphur: theſe are, vitriolated vegetable and mineral alkali.

Middle Earthy Salts. Of the middle earthy ſalts, few flow ſo perfectly as to be reduced to a globule; nor do they all fuſe actually, though the water of cryſtallization in its departure excites a foam: thoſe which contain vitriolic acid efferveſce violently with borax and microcoſmic ſalt, but are difficultly diſſolved by ſal ſodæ.

Decrepitating Earthy Salts. Gypſum ſpathoſum.

Intumeſcent Earthy Salts. Vitriolated magneſia ſwells, foams, and, when repeatedly expoſed to the flame, may be fuſed.

Alum is ſomewhat different; for finally all ebullition ceaſes, and the maſs remains immovably at reſt, and it undergoes no other change than to ſplit: when hot, it is variegated with blue ſpots.

Acetated lime ſwells much like alum, but ſcarcely adheres to the charcoal.

Nitrated magneſia ſwells with a crackling noiſe, but without any detonation.

Salited magneſia, in a dry ſtate, belongs to this claſs.

Fuſible Salts. Although gypſum eluded the force of fire in Pott's furnace, yet it may be fuſed in a moment if a ſection of the lamella be expoſed in the blue flame: though naturally pellucid, it inſtantly acquires an opacity; the water goes off without ebullition.

Carbo-

Carbonaceous Earthy Salts. Tartarized lime and magneſia: nay, all the earths united with acid of tartar.

Soluble in borax and microcoſmic ſalt, with efferveſcence. Lime, magneſia, vitriolated clay, and acetated lime.

Middle Metallic Salts. Some of the middle metallic ſalts, either containing a large quantity of water, or retaining pertinaciouſly the acid, flow in the fire; others only foam: moſt of them recover, at leaſt partly, their metallic appearance, eſpecially when they touch the coal, leaving at the ſame time an irregular ſcoria. By the addition of borax, the ſcoriæ are diſſolved, and the regulus better collected; but here we conſider the ſalts alone: the fluxes are tinged in the ſame way as by the metal calxes.

Decrepitating Metallic Salts. Nitrated lead, tartarized antimony.

Volatile Metallic Salts. To this belong the ſalts whoſe baſe is mercury, as they are diſſipated by fire: thoſe which contain marine acid, in general, fly off more quickly than thoſe which are loaded by any other menſtruum.

Detonating Metallic Salts. Silver, mercury, lead and biſmuth, united with nitrous acid.

Intumeſcent Metallic Salts. At the firſt approach of fire they ſwell with noiſe, and a certain ebullition, but then remain immovable. Vitriolated and nitrated copper, iron and cobalt vitriolated, vitriolated and nitrated zinc.

Fuſible Metallic Salts. Theſe are by the exterior flame eaſily reducible to globules. By this method, ſilver and lead, ſalited in the ſpoon, put on the corneous appearance; but by a long violent fuſion they again put it off, the acid being too much diminiſhed: hence it appears with what caution theſe metals are to be made horny in the crucible. Silver and lead vitriolated, copper and zinc ſalited.

Carbonaceous Metallic Salt. Tartarized antimony.

Metallic Salts tinging the flame. Vitriolated copper, and alſo ni trated copper, produce a greenneſs; but ſalited copper acts with far more efficacy. The green cryſtals of this firſt grow red by the exterior flame; they ſoon liquefy and grow black; they make the flame at firſt of a deep blue, which afterwards verges to a green. The flame, thus tinged, expands much, and remains ſo until the whole maſs of the ſalt is diſſipated: this green ſalt, added to microcoſmic ſalt in fuſion, immediately ſhews a beautiful flame; the clear globule is tinged green, and does not grow opake or brown, unleſs a large quantity of the microcoſmic ſalt be added; a circumſtance which takes place much ſooner upon the addition of a ſmaller quantity of borax.

Habitudes of the Primitive Earths.

Lime.

This (which by itſelf is infuſible), by a ſufficient degree of heat, loſes its property of efferveſcing in acids; it acquires ſolubility in water, the power of generating heat with it, and of ſuffering ſpontaneous calcination. Theſe laſt properties, however, it loſes, if too much urged by heat. The heat it generates with water, may eaſily be tried by a drop of water on the back of the hand, with the addition of a ſmall piece of lime, juſt cooled after burning.

Crude calcareous earth efferveſces a little with mineral alkali, and is divided into ſmall particles, but ſparingly diſſolved: when overburned, it ſeems not to be divided or diminiſhed.

In

In borax the former diſſolves with efferveſcence; the latter ſcarcely generates any bubbles.

In microcoſmic ſalt the ſame phenomena appear; but the efferveſcence is ſomewhat greater.

It is alſo obſervable, that a very ſmall piece of calcareous earth is eaſily diſſolved in borax and microcoſmic ſalt, yielding ſphærules altogether pellucid: but if more earth be gradually added, the flux, at length ſaturated, retains the diſſolved matter, indeed, while in perfect fuſion; but on removing the flame, the part which was taken up by means of the heat alone, ſeparates; from hence clouds ariſe at firſt, and the whole globule becomes opake, and recovers its tranſparency again by fuſion. This is entirely correſpondent to what happens in the humid way: for warm water ſaturated with nitre, or Glauber's ſalt, upon cooling, is obliged to depoſit that part which it had taken up in virtue of its warmth. If the fuſed pellucid globule (which would grow opake upon cooling) be quickly plunged into melting tallow, water, or any other ſubſtance hot (for cold generally cracks it), ſo as to grow ſuddenly hard, it retains its tranſparency; the particles being as it were fixed into that ſtate which is neceſſary to tranſparency. This is a phenomenon highly worthy of obſervation, which cannot be ſeen in the crucible.

Terra Ponderoſa.

Terra ponderoſa, expoſed alone to the flame, becomes like calcareous earth, cauſtic, ſoluble in water, and non efferveſcent in acids.

In ſal ſodæ it efferveſces only a little, but is ſenſibly diminiſhed.

In borax it diſſolves with ſlight efferveſcence; as alſo in microcoſmic ſalt; but here it efferveſces ſomewhat more violently.

The phenomena obſerved on ſaturation with calcareous earth have place here alſo: magneſia ignited alone loſes its aërial acid, together with the property of efferveſcing in acids; in ſal ſodæ it efferveſces a little, but is ſcarcely diminiſhed.

Clay.

Common argillaceous earth abounds with heterogeneous particles, and always contains a conſiderable quantity of ſiliceous earth, which generally amounts to half; hence, when clay is required pure, as in this inſtance, the earth of alum, digeſted in an alkaline lixivium and well waſhed, muſt be employed.

Expoſed to the flame, it grows hard, contracts its bulk, but does not fuſe.

In ſal ſodæ it efferveſces a little, but is ſparingly diſſolved.

In borax it diſſolves with remarkable efferveſcence.

In microcoſmic ſalt, a ſtill more violent ebullition takes place.

Siliceous Earth.

Alone it is not fuſed.

Sal ſodæ diſſolves it with violent efferveſcence; and if the ſiliceous earth diſſolved exceeds the weight of the flux, it yields a pellucid glaſs. This, and all the other operations with ſal ſodæ, muſt be performed in the ſpoon.

In borax it diſſolves ſlowly, without any ebullition; in microcoſmic ſalt, very ſlowly, and without efferveſcence.

Derivative Earths.

To avoid confuſion from multiplicity, we ſhall collect theſe into claſſes, according to their moſt remarkable habits.

Decrepitating.

Spathoſe mineral fluor. Lapis ponderoſus*. Calcareous ſpar. Spathum ponderoſum. The decrepitation may be performed without ſcattering in a glaſs tube, cloſed by the finger, and held over the flame.

Infuſible.

Diamond. Pure aſbeſtos †. Refractory clay †. Hyacinth. Hydrophanous ſiliceous jaſper. Lapis ponderoſus. Pura mica †. Quartz. Ruby. Sapphire. Flint. Steatite †. Topaz.

Thoſe four marked with a † are indurated by fire.

Infuſible, changing colour.

Bolar earths generally grow black; lime mixed with aërated magneſia, black; lime blackened by ſubtile bitumen, white.

Of the gems, ſome change or loſe colour; theſe are the cryſolith, topaz, and ſometimes the ſapphire.

The red and green jaſper acquire a whitiſh or grey colour.

Green, black, and red ſteatite grow white.

Fuſible without ebullition.

Martial aſbeſtos. Augites (aqua marina †). Baſaltes. § Cryſolith †. Mineral fluor. Granite. Marga. Petroſilex. Emerald †. Spathum ponderoſum. (This corrodes the charcoal, and acquires an hepatic taſte.) Spathum pyromachum. Trapp.

The earths marked with a † do not but with great difficulty ſhew any ſigns of fuſion.

Fuſible with ebullition.

Lithomarga. Schoerl ‖. Turmalin. The inflated ſcoria quickly grows white, though the ſtone is brown. Zeolith.

Fuſible altogether in ſal ſodæ, and with effervеſcence.

Achates. Chalcedony. Cornelian. Cos Turcica †. Mineral fluor †. Onix. Opal. Quartz. Common flint. Spathum ponderoſum.

Theſe marked † efferveſce but little.

* This is the name given by Mr. Cronſtedt (§ 209) to a foſſile, which he enumerates among the ores of iron, and which poſſeſſes a peculiar ſpecific gravity. Scheele, Bergmann, and De Luyart have examined it, and found it to conſiſt chiefly of lime and a peculiar acid. This ſtone is now better known by its Swediſh name TUNGSTEN; which ſee, and alſo its acid.

§ The yellowiſh cryſtalline matter which fills up the interſtices of the native Siberian iron exhibit the ſame properties with reſpect to fire as the cryſolith.

‖ Bergmann uſes the words Schoerl and Trapp, which are now known all over Europe. By baſaltes he underſtands larger priſms, which compoſe the Giant's Cauſeway, Staffa, and other columnar mountains.

Diviſible

Diviſible with or without efferveſcence in ſal ſodæ, but not entirely ſoluble.

Amianthus. Aſbeſtos. Baſaltes. Cryſolite. Garnet †. Hornblende. Jaſper. Lapis ponderoſus. Lithomarga. Mica. Matrix of the alum of Tolfa. Petroſilex. Aluminous ſchiſt. Tegular ſchiſt, or roof ſlate of Helſing. Emerald. Spathum pyromachum. Steatites. Talc. Trapp. Trippel. Tourmalin.

Not fuſible, or diviſible by ſal ſodæ.

Diamond. Hyacinth. Ruby. Sapphire. Topaz.

Soluble in borax, with more or leſs efferveſcence.

Mineral fluor †. Marga. Mica †. Ore of Tolfa. Aluminous ſchiſt Tegular ſchiſt of Helſing † (Roof Slate). Spathum ponderoſum. Schoerl. Talc. Tourmalin.

Thoſe marked † efferveſce but little.

Soluble in borax, without efferveſcence.

Agate. Diamond. Amianthus. Aſbeſtos. Baſaltes. Chalcedony. Cornelian. Cryſolite. Cos Turcica. Garnet. Hyacinth. Hydrophanous ſiliceous jaſper. Lapis ponderoſus. (The flux grows hardly blue ; on too much cooling it becomes white and opake.) Lithomarga. Onyx. Opal. Petroſilex. Quartz †. Ruby. Sapphire. Common flint †. Emerald. Steatites. Spathum pyromachum. Trapp. Trippel. Topaz †. Zeolite.

Thoſe marked † require a greater quantity of flux and longer heat than the reſt.

Soluble in microcoſmic ſalt, with more or leſs efferveſcence.

Baſaltes †. Cos Turcica. Mineral fluor †. Lapis ponderoſus. It efferveſces at firſt, then ſcarcely diſſolves : the flux acquires a fine blue tinge, without any mixture of redneſs. The colour is diſcharged by the exterior flame, or by a ſmall quantity of nitre ; but is reſtored by the interior flame : if the proportion of earth be large, it acquires a pellucid brown colour, not diſchargeable either by nitre or the flame ; if ſtill larger, it grows black and opake. Marle. Mica †. Aluminous ore of Tolfa. Aluminous ſchiſtus. Tegular ſchiſtus of Helſing †. Schoerl. Spathum ponderoſum. Tourmalin.

Thoſe marked † efferveſce but little.

Soluble in microcoſmic ſalt, without efferveſcence.

Agate. Diamond. Amianthus. Aſbeſtos. Chalcedony †. Cornelian †. Cryſolith †. Granite. Hornblende. Hyacinth. Hydrophanous ſiliceous jaſper †. Lithomarga. Onyx †. Opal †. Petroſilex. Quartz †. Ruby. Sapphire. Common flint. Emerald. Steatites, Spathum pyromachum. Talc. Topaz. Trapp. Trippel. Zeolite.

Thoſe marked † are more difficultly diſſolved than the reſt, and ſcarce ſenſibly.

In general it is to be obſerved, 1. That when the efferveſcence is to be examined, only a very ſmall piece of the matter is to be added to the flux, as the moſt ſubtile powder contains air, which being expelled by the heat, forms the appearance of efferveſcence. 2. That the ſolution is often accelerated by lime, ſpathum ponderoſum, gypſum, and other additaments, both in borax and microcoſmic ſalt. 3. That gypſum alone is ſometimes an excellent and very uſeful

flux. This ſalt, with an equal portion of fluor mineral, is eaſily reduced to a pellucid globule, which yet upon cooling grows white and opaque. The ſpathum ponderoſum alſo unites with mineral fluor, but the maſs does not become pellucid.

BLUE, PRUSSIAN. A combination of iron with a ſubſtance of the nature of an acid, and diſtinguiſhed by the name of the *acid of Pruſſian blue*; which ſee.

A caſual circumſtance occaſioned the diſcovery of this pigment. Dieſbach, a chemiſt of Berlin, being deſirous of precipitating a decoction of cochineal with fixed alkali, borrowed a quantity of alkali of Dippel, from which he had ſeveral times diſtilled his animal oil; and as the decoction of cochineal contained martial vitriol, a beautiful blue precipitate fell down. An account of Pruſſian blue was given in the Memoirs of the Academy of Berlin, in the year 1710, but with no intimation of the proceſs. It was afterwards rendered public by Woodward, in the Philoſophical Tranſactions, who declared that he had received it from one of his friends in Germany.

To make Pruſſian blue, four ounces of alkali are mixed with an equal weight of dried bullock's blood, and the mixture is expoſed to ignition in a covered crucible. By this treatment a coal is obtained, which is afterwards lixiviated in water, filtered, and concentrated by evaporation. The liquor is known by the name of the Phlogiſticated Alkali. On the other hand, two ounces of martial vitriol and four ounces of alum are diſſolved in a pint of water. The two ſolutions are then mixed, and a blueiſh depoſition falls down, which is rendered ſtill more intenſely blue by waſhing it with marine acid.

This is the proceſs uſed in chemical laboratories; but another method is followed in the manufactories. The raſpings of horns, clippings of ſkins, or other animal ſubſtances, are converted into charcoal, by heating them in covered veſſels. Thirty pounds of potaſh are then mixed with ten pounds of this coal, and the mixture calcined in an iron veſſel. After twelve hours ignition, the mixture acquires the form of a ſoft paſte, which is poured out into veſſels of water. The water is then filtered, and the ſolution mixed with another, conſiſting of three parts of alum, and one of martial vitriol.

Various theories have been exhibited reſpecting Pruſſian blue by Geoffroy, Macquer, Sage, and others, in which conſiderable ingenuity is diſplayed relative to the ſtate of chemical knowledge at the time they were exhibited: but the diſcoveries of Scheele and Berthollet have afforded us much light with reſpect to the analyſis of this ſubſtance, for which conſult the article laſt referred to.

BLUE, SAXON. The beſt Saxon blue colour may be given by the following compoſition:

Mix one ounce of the beſt powdered indigo with four ounces of oil of vitriol, in a glaſs body or matraſs, and digeſt it for one hour with the heat of boiling water, ſhaking the mixture at different times: then add twelve ounces of water to it, and ſtir the whole well, and, when grown cold, filter it. This produces a very rich deep colour. If a paler blue be required, it may be obtained by the addition of more water. The heat of boiling water is ſufficient for this operation, and can never ſpoil the colour: whereas a ſand heat, which is commonly uſed, is often found to damage the colour. Indigo which has been digeſted with a large quantity of ſpirit of wine, and then dried, will produce a finer colour than the former, if treated in the ſame manner with oil of vitriol.

BOG ORES. Theſe are ores of iron, conſiſting of a calx of the metal in a ſtate

a ſtate of greater or leſs purity, mixed with earth chiefly of the argillaceous kind. They appear to have been depoſited by water, and are uſually diſpoſed in ſtrata, ſeparated into ſmall priſmatic parts by the contraction of the clay.

The chief of theſe are, theætites, or eagle-ſtone, with other round pieces or pebbles; and the hæmatites, or blood-ſtone.—*See* IRON.

BOLE. Various indurated clays have been diſtinguiſhed by this name, which was formerly much uſed: but, as it has been very little noticed, as a term, by the later improvers of mineralogical and chemical ſcience, its preſent ſignification is very indeterminate.

BOLOGNIAN STONE. Lemery *reports, that an Italian ſhoemaker, named Vincenzo Caſciarolo, firſt diſcovered the phoſphoric property of the Bolognian ſtone. It is the ponderous ſpar, or combination of vitriolic acid with ponderous earth. This man found it at the foot of mount Paterno; and, from its brilliancy and weight, was led to ſuppoſe that it contained ſilver. Having expoſed it to the fire, doubtleſs with the intention of diſcovering that precious metal, he obſerved that it was luminous in the dark; a diſcovery which engaged his attention, and was frequently repeated with ſucceſs. Many philoſophers and chemiſts have ſince examined this phenomenon, and have varied the method of calcining the Bolognian ſtone in many reſpects. It ſeems as if the greateſt degree of phoſphoreſcence depended on a due application of the heat; but many trivial circumſtances were noticed by the earlier chemiſts, which in all probability had little to do in producing this effect. An extreme degree of heat fuſes this ſtone.

BONE. The bones of men and quadrupeds owe their great firmneſs and ſolidity to a conſiderable portion of the phoſphoric ſalt of lime which they contain. When theſe are raſped ſmall, and boiled in water, they afford gelatinous matter, and a portion of fat or oil which occupied their interſtices. By deſtructive diſtillation they afford alkaline phlegm, a fetid oil, and much volatile alkali, leaving a coal not eaſily burned. In an open fire, bones are inflamed by virtue of their oil, and emit an offenſive empyreumatic ſmell. The white, friable, and incombuſtible reſidue conſiſts chiefly of lime and phoſphoric acid in combination. It affords a ſmall quantity of mild mineral alkali by waſhing with water. This white matter is decompoſable by fuſion with mild fixed alkalis, which unite with the phoſphoric acid, at the ſame time that the fixed air converts the lime into chalk. Acids likewiſe diſengage the phoſphoric acid by uniting with the lime. The nitrous or the vitriolic acids are moſt commonly uſed in this proceſs.

BORAX. The origin of borax was for a long time unknown in Europe; and many chemiſts ſtill continue to copy from each other that its origin has not yet been aſcertained. Mr. Grill Abrahamſon, however, ſent ſome to Sweden in the year 1772, in a cryſtalline form, as dug out of the earth in Thibet, where it is called Pounnxa, Mypoun, and Houipoun: it is ſaid to have been alſo found in Saxony in ſome coal pits †. But the moſt particular accounts we poſſeſs concerning the origin of borax, are found in the Philoſophical Tranſactions for 1787. Mr. Blane, who had an opportunity of enquiring of ſome of the inhabitants of the place where the borax is made, gives the following account:

This ſaline ſubſtance, called in the language of the country Swagah, is brought into Hindoſtan from the mountains of Thibet. The place where it is produced, is in the kingdom of Jumlate, diſtant from Betowle about thirty days

* Courſe of Chemiſtry, tranſlated by Keill, page 709. † Kirwan's Mineralogy, 206.

journey north. Jumlate is the largeſt of the kingdoms in that part of the Thibet mountains, and is conſidered as holding a ſuperiority over all the reſt.

The place where the borax is produced, is deſcribed to be in a ſmall valley ſurrounded with ſnowy mountains, in which is a lake about ſix miles in circumference, the water of which is conſtantly hot, ſo much ſo that the hand cannot be held in it for any time. The ground round the banks of the lake is perfectly barren, not producing even a blade of graſs; and the earth is full of a ſaline matter in ſuch plenty, that, after falls of rain or ſnow, it concretes in white flakes upon the ſurface, like the natron in Hindoſtan. Upon the banks of this lake, in the winter ſeaſon, when the falls of ſnow begin, the earth is formed into ſmall reſervoirs, by raiſing it into banks about ſix inches high: when theſe are filled with ſnow, the hot water from the lake is thrown upon it, which, together with the water from the melted ſnow, remains in the reſervoir, to be partly abſorbed by the earth, and partly evaporated by the ſun; after which there remains at the bottom a cake, of ſometimes half an inch thick, of crude borax, which is taken up, and reſerved for uſe. It can only be made in the winter ſeaſon; becauſe the falls of ſnow are indiſpenſably requiſite, and alſo becauſe the ſaline appearances upon the earth are ſtrongeſt at that ſeaſon. When once it has been made upon any ſpot, in the manner above deſcribed, it cannot be made again upon the ſame place till the ſnow ſhall have fallen upon it, and diſſolved three or four times; after which the ſaline efflorеſcence re-appears, and it is again fit for the operation.

The borax, in the ſtate above deſcribed, is tranſported from hill to hill upon goats, and paſſes through many different hands before it reaches the plains, which increaſes the difficulty of obtaining authentic information regarding the original manufacture. When brought down from the hills, it is refined from the earth and groſs impurities, by boiling and cryſtallization. Mr. Blane could obtain no anſwers to any queſtions regarding the quality of the water, and the mineral productions of the ſoil. All they could ſay of the former was, that it was very hot, very foul, and as it were greaſy; that it boils up in many places, and has a very offenſive ſmell: and the latter remarkable only for the ſaline appearances above deſcribed. That country, however, in general, produces conſiderable quantities of iron, copper, and ſulphur. After being purified, it ſells in the market here for about fifteen rupees per maund; and he was aſſured by many of the natives, that all the borax in India comes only from the place above mentioned.

The other account of borax, in the ſame volume of the Tranſactions, is contained in a letter from father Joſeph de Rovato, father prefect of the miſſion in Thibet, who received the information from a native of the country where the borax is prepared, ſent expreſsly for that purpoſe to him by the brother of the king of Nepal, a kingdom on the borders of Thibet.

This man, partly in the Nepaleſe, and partly in the Hindoo language, both which are underſtood by the prefect, gave the following account:—In the province or territory of Marmé, twenty-eight days journey to the north of Nepal, and twenty-five to the weſt of Laſſa, the capital of Thibet, there is a vale about eight miles broad. In a part of this vale there are two villages or caſtles, the one named Scierugh, and the other Kanglé, the inhabitants of which are wholly employed in digging the borax which they ſell into Thibet and Nepal, they having no other means of ſubſiſtence, the ſoil being ſo barren as to produce nothing but a few ruſhes. Near the two above-mentioned caſtles there is a pool of moderate

rate ſize, and ſome ſmaller ones, where the ground is hollow, in which the rain water collects. In theſe pools, after the water has been ſome time detained in them, the borax is formed naturally: the men wading into the water, feel a kind of pavement under their feet, which is a ſure indication that borax is there formed, and there they accordingly dig it.

Where there is little water, the layer of borax is thin; and where it is deep, it is thicker; and over the latter there is always an inch or two of ſoft mud, which is probably a depoſit of the water after it has been agitated by rain or wind. Thus is the borax produced merely by nature, without either boiling or diſtillation. The water in which it is formed is ſo bad, that the drinking a ſmall quantity of it will occaſion a ſwelling of the abdomen, and in a ſhort time death itſelf. The earth that yields the borax is of a whitiſh colour; and in the ſame valley, about four miles from the pools, there are mines of ſalt, which is there dug in great abundance for the uſe of all the inhabitants of theſe mountains, who live at a diſtance from the ſea. The natives, who have no other ſubſiſtence on account of the ſterility of the ſoil, pay nothing for digging borax; but ſtrangers muſt pay a certain retribution, and uſually agree at ſo much a workman. This is paid to a Lama, named Pema Tupkan, who owns the pits in Marmé.

Ten days journey farther north there is another valley, named Tapré, where they dig borax, and another ſtill farther, called Cioga; but of this latter the prefect did not mark the ſituation. Borax is, in the Hindoo and Nepaleſe languages, called Soaga. If it be not purified, it will eaſily deliqueſce; and in order to preſerve it any time till they have an opportunity of ſelling it, the people often mix it with earth and butter.

It does not appear that borax was known to the ancients, their chryſocolla being a very different ſubſtance, compoſed of the ruſt of copper, triturated with urine. The word borax is found for the firſt time in the works of Geber.

Borax is not only found in the Eaſt, but likewiſe in South America. Mr. Anthony Carera *, a phyſician eſtabliſhed at Potoſi, informs us, that this ſalt is abundantly obtained at the mines of Riquintipa, and thoſe in the neighbourhood of Eſcapa, where it is uſed by the natives in the fuſion of copper ores.

The purification of borax by the Venetians and the Hollanders, was for a long time among thoſe ſecrets which the want of a ſufficient ſpirit of reſearch prevented from becoming general: chemical writers have been ſatisfied in aſſerting that the proceſſes conſiſted of ſolution, filtration, cryſtallization, and calcination. Chaptal, however, informs us, from his own extenſive experience, that the deſtruction of the oily part of borax by calcination is attended with conſiderable loſs. He finds, after trying all the proceſſes in the large way, that the ſimpleſt method conſiſts in boiling the borax ſtrongly, and for a long time, with water. This ſolution being filtered affords by evaporation cryſtals, which are ſomewhat foul, but may be purified by repeating the operation.

Purified borax is white, tranſparent, rather greaſy in its fracture, affecting the form of ſix-ſided priſms, terminating in three-ſided or ſix-ſided pyramids. Its taſte is ſtyptic; it converts ſyrup of violets to a green, and, when expoſed to heat, it ſwells up, boils, loſes its water of cryſtallization, and becomes converted into a porous, white, opaque maſs, commonly called Calcined Borax. A ſtronger heat brings it into a ſtate of quiet fuſion: but the glaſſy ſubſtance thus afforded, which

* Quoted by Chaptal in his Elements of Chemiſtry.

is

is tranſparent, and of a greeniſh yellow colour, is ſoluble in water, and efflo-reſces in the air.

This ſalt requires about eighteen times its weight of water to diſſolve it at the temperature of ſixty degrees of Fahrenheit; but water at the boiling heat diſſolves three times this quantity. Borax is uſed as an excellent flux in docimaſtic operations. It enters into the compoſition of reducing fluxes, and is of the greateſt uſe in analyſes by the blow-pipe. It may be applied with advantage in glaſs manufactories; for when the fuſion turns out bad, a ſmall quantity of borax re-eſtabliſhes it. It is more eſpecially uſed in ſoldering: it aſſiſts the fuſion of the ſolder, cauſes it to flow, and keeps the ſurface of the metals in a ſoft or clean ſtate, which facilitates the operation. It is ſcarcely of any uſe in medicine. Sedative ſalt alone is uſed by ſome phyſicians; and its name ſufficiently indicates its ſuppoſed effects.

Borax has the inconvenience of ſwelling up, and requires the greateſt attention on the part of the artiſt who uſes it in delicate works, more eſpecially when deſigns are to be formed with gold of different colours. It has been long a deſideratum to ſubſtitute ſome compoſition in the room of borax, which might poſſeſs its advantages without its defects.

M. Georgi has publiſhed the following proceſs:—"Natron, mixed with marine ſalt and Glauber's ſalt, is to be diſſolved in lime water; and the cryſtals which ſeparate by the cooling of the fluid may be ſet apart. The lixivium of natron is then to be evaporated; and this ſalt afterwards diſſolved in milk. The evaporation affords ſcarcely one-eighth of the natron employed; and the reſidue may be applied to the ſame uſes as borax."

Meſſrs. Struve and Exchaquet have proved that the combination of phoſphoric acid and vegetable alkali, fuſed with a due proportion of phoſphorated lime, forms an excellent glaſs for ſoldering metals.

BOVEY COAL. Xylanthrax. This is of a brown or browniſh black colour, and lamellar texture; the laminæ are frequently flexible when firſt dug, though generally they harden when expoſed to the air. It conſiſts of wood penetrated with petrol or bitumen, and frequently contains pyrites, alum and vitriol; its aſhes afford a ſmall quantity of fixed alkali, according to the German chemiſts *; but according to Mr. Mills †, they contain none. By diſtillation it yields an ill-ſmelling liquor, mixed with volatile alkali and oil, part of which is ſoluble in ſpirits of wine, and part inſoluble, being of a mineral nature.

It is found in England, France, Italy, Switzerland, Germany, Iceland, &c.

BRANDY. This well-known fluid is the ardent ſpirit diſtilled from wine. The greateſt quantities are made in Languedoc, where this manufacture, upon the whole ſo pernicious to ſociety, firſt commenced. It is obtained by diſtillation in the uſual method, by a ſtill, which contains five or ſix quintals of wine, and has a capital and worm tub applied. Its peculiar flavour depends, no doubt, on the nature of the volatile principles, or eſſential oil, which come over along with it, and likewiſe, in ſome meaſure, upon the management of the fire, the wood of the caſk in which it is kept, &c. It is ſaid, that our rectifiers imitate the flavour of brandy, by adding a ſmall proportion of nitrous acid to the ſpirit of malt or melaſſes. *See* SPIRIT OF WINE.

BRASS. An elegant yellow-coloured compound metal, conſiſting of cop-

* 2 Gerb. Beytr. 271. † Phil. Tranſ. 1760.

per

per combined with about one-third of its weight of zinc. The beſt braſs is made by cementation of calamine, or the ore of zinc, with granulated copper. *See* COPPER.

BRASSICA RUBRA. Mr. Watt finds that the red cabbage affords a very excellent teſt, both for acids and alkalis; in which it is ſuperior to litmus, being naturally blue, turning green with alkalis, and red with acids; beſides which it poſſeſſes the advantage of not being affected by the fuming nitrous acid, any further than as it acts as a real acid. The management of the leaves to procure this teſt, is as follows, in the words of the author *:

"To extract the colouring matter, take thoſe leaves of the cabbage which are freſheſt, and have moſt colour; cut out the larger ſtems, and mince the thin parts of the leaves very ſmall; then digeſt them in water of about the heat of one hundred and twenty degrees for a few hours, and they will yield a blue liquor, which, if uſed immediately as a teſt, will be found to poſſeſs great ſenſibility. But as this liquor is very apt to turn acid and putrid, and to loſe its ſenſibility when it is wanted to be preſerved for future uſe, the following proceſſes ſucceed the beſt:

1. After having minced the leaves, ſpread them on paper, and dry them in a gentle heat; when perfectly dry, put them up in glaſs bottles well corked; and when you want to uſe them, acidulate ſome water with vitriolic acid, and digeſt or infuſe the dry leaves in it until they give out their colour; then ſtrain the liquor through a cloth, and add to it a quantity of fine whiting or chalk, ſtirring it frequently until it becomes of a true blue colour, neither inclining to green nor purple: as ſoon as you perceive that it has acquired this colour, filter it immediately, otherwiſe it will become greeniſh by longer ſtanding on the whiting.

This liquor will depoſit a ſmall quantity of gypſum, and by the addition of a little ſpirit of wine will keep good for ſome days, after which it will become a little putrid and reddiſh. If too much ſpirit is added, it deſtroys the colour. If the liquor is wanted to be kept longer, it may be neutralized by means of a fixed alkali inſtead of chalk.

2. But as none of theſe means will preſerve the liquor long, without requiring to be neutralized afreſh, juſt before it is uſed; and as the putrid and acid fermentation which it undergoes, and perhaps the alkalis or ſpirit of wine mixed with it, ſeem to leſſen its ſenſibility; in order to preſerve its virtues while it is kept in a liquid ſtate, ſome freſh leaves of the cabbage, minced as has been directed, may be infuſed in a mixture of vitriolic acid and water, of about the degree of the acidity of vinegar: and it may be neutralized, as it is wanted, either by means of chalk, or of the fixed or volatile alkali. But it is neceſſary to obſerve, that if the liquor has an exceſs of alkali, it will ſoon loſe its colour, and become yellow, from which ſtate it cannot be reſtored; therefore care ſhould be taken to bring it very exactly to a blue, and not to let it verge towards a green †.

By the ſame proceſs I have made a red infuſion of violets, which, on being neutralized, forms at preſent a very ſenſible teſt: but how long it will preſerve its properties I have not yet determined. Probably the coloured infuſions of other

* Phil. Tranſ. vol lxxiv.

† Since writing the above, I have found that the infuſions of red cabbages and of various flowers in water, acidulated by means of vitriolic acid, are apt to turn mouldy in the ſummer ſeaſon, and alſo, that the moulding is prevented by the addition of ſpirits of wine. The quantity of ſpirit which is neceſſary for this purpoſe, I have not been able to aſcertain; but I add it by a little at a time, until the progreſs of the moulding is prevented. Watt.

flowers may be preſerved in the ſame manner, by the antiſeptic power of the vitriolic acid, ſo as to loſe little of their original ſenſibility. Paper freſh ſtained with theſe teſts in their neutral ſtate, has ſufficient ſenſibility for many experiments: but the alum and glue which enter into the preparation of writing paper, ſeem in ſome degree to fix the colour; and paper which is not ſized becomes ſomewhat tranſparent when wetted, which renders ſmall changes of colour imperceptible; ſo that, where accuracy is required, the teſt ſhould be uſed in a liquid ſtate *."

BRAZIL WOOD. This wood is of the growth of the Brazils in South America, and alſo of the Iſle of France, Japan, and elſewhere. It is chiefly uſed in the proceſſes of dying. This wood is conſiderably hard, is capable of a good poliſh, and is ſo heavy, that it ſinks in water. Its colour is pale when newly cut, but it becomes deeper by expoſure to the air. The various ſpecimens differ in the intenſity of their colour; but the heavieſt is reckoned the moſt valuable. It has a ſweetiſh taſte when chewed, and is diſtinguiſhed from red ſanders, or ſandal, by its property of giving out its colour with water, which this laſt does not.

If the Brazil wood be boiled in water for a ſufficient time, it communicates a fine red colour to that fluid. The reſidue is very dark coloured, and gives out a conſiderable portion of colouring matter to a ſolution of alkali. Ardent ſpirit extracts the colour from Brazil wood, as does likewiſe the volatile alkali; and both theſe are deeper than the aqueous ſolution. The ſpirituous tincture, according to Dufay, ſtains warm marble of a purpliſh red, which on increaſing the heat becomes violet; and if the ſtained marble be covered with wax, and conſiderably heated, it changes through all the ſhades of brown, and at laſt becomes fixed of a chocolate colour.

The recent decoction of Brazil wood, according to Berthollet †, affords, by the addition of vitriolic acid, a precipitate, ſmall in quantity, and of a red colour inclining to yellow; the liquor remaining tranſparent, and of a yellow colour. The nitrous acid firſt converts the tincture to a yellow; but if the quantity of acid be increaſed, the liquor aſſumes a deep orange yellow, and becomes tranſparent, after depoſiting a precipitate of the ſame colour nearly as the foregoing, but more abundant. The muriatic acid has the ſame effect as the vitriolic. The ſaccharine or oxalic acid affords an orange red, or almoſt ruddy precipitate, nearly as abundant as that thrown down by the nitrous acid, and the liquor remains tranſparent and yellow. Diſtilled vinegar affords a very ſparing precipitate of the ſame colour; the fluid continuing tranſparent, but rather of a deeper orange. Tartar affords ſtill leſs precipitate; and the remaining liquor is turbid and more reddiſh than the laſt. Fixed alkali converts the colour of the decoction to a crimſon or deep violet, inclining to brown, and affords a precipitate of the ſame colour, though very ſmall in quantity. Volatile alkali affords a brighter violet or purple, and a little precipitate of a fine purple. Alum throws down a red precipitate inclining to crimſon, which is abundant and ſubſides very ſlowly; while the ſupernatant fluid preſerves its fine red colour, like that of the recent decoction: this liquor affords another abundant precipitate, if the acid of the alum be ſaturated with an alkali. In this manner is prepared a kind of carmine, inferior in beauty

* I have found that the petals of the ſcarlet roſe, and thoſe of the pink-coloured lychnis, treated in this manner, afford very ſenſible teſts. Watt.

† In his Elémens de l'Art de la Teinture, from which the preſent article is chiefly extracted. Dr. Hamilton promiſes a tranſlation of this excellent work.

to the common carmine, and likewiſe a liquid lake for miniature painters. Alum and tartar together afford a browniſh red precipitate in ſmall quantity, while the fluid remains of a bright orange red. Vitriol of iron gives the tincture a black colour, inclining to violet, at the ſame time that an abundant precipitate of the ſame colour falls down. Vitriol of copper likewiſe affords a plentiful brown precipitate, and converts the fluid to a tranſparent browniſh red. Vitriol of zinc throws down a ſparing brown precipitate, leaving the fluid of an amber colour. Solution of ſugar of lead affords a precipitate of deep red, of conſiderable beauty, and the liquor becomes of an orange red. The ſolution of tin in aqua regia occaſions an abundant precipitate of a fine roſe colour, and the fluid remains clear and quite colourleſs. Laſtly, corroſive ſublimate occaſions a ſlight brown precipitate; the liquor remaining tranſparent, and of a fine yellow colour.

The Journal de Phyſique for February 1785 contains ſome curious experiments reſpecting the action of acids upon the colour of Brazil wood. If the aqueous tincture of this wood be firſt rendered yellow by means of tartar and the acetous acid, and the ſolution of tin in aqua regia be then poured in, a very abundant roſe-coloured precipitate is obtained: if to the ſolution rendered yellow by an acid there be added a greater quantity of the ſame or a ſtronger acid, the red colour is reſtored; the vitriolic acid is beſt adapted to this effect. Several ſalts likewiſe cauſe the red colour of Brazil wood to appear again after it has been deſtroyed by the action of acids.

It has been obſerved that the recent decoction of Brazil wood is leſs proper for dying than that which is older, or even fermented; it aſſumes a yellowiſh red colour by age. Hellot recommends the hardeſt waters for making this decoction; but it muſt be obſerved that ſuch waters deepen the colour, by virtue of the earthy ſalts they contain. After boiling the chips of this wood for three hours, this firſt decoction is put into a caſk. More water is then added to the wood, which is boiled for a ſecond three hours, and the decoction added to the foregoing. In this, as in all decoctions of colouring wood, the wood is kept in a bag of porous cloth.

Wool plunged in the decoction of Brazil wood acquires a weak colour, which ſoon goes off. It therefore requires a preparation to render the dye permanent.

The wool muſt be boiled in a ſolution of alum, to which one fourth or even a leſs quantity of tartar has been added. A larger proportion of tartar would render the colour deeper. The impregnated wool is kept at leaſt eight days in a cool place; after which it is dyed in the decoction of Brazil wood by a gentle boiling. As the colouring matter firſt depoſited affords an inferior dye, it is proper to dip a coarſer ſtuff firſt. In this way a lively red dye is obtained, which reſiſts the air very well.

If the red colour of Brazil wood be deſtroyed by an acid, it communicates a very durable fawn colour to woollen ſtuffs.

M. Poerner prepares the ſtuff by boiling it in a ſolution of tin, alum, and a little tartar; and he makes his bath with the Brazil wood, and a conſiderable proportion of alum. In the reſidue of this bath he dips another piece which has received the ſame preparation. The firſt piece receives a fine brick colour, and the ſecond a dye approaching to ſcarlet *. The ſhades may be greatly varied by altering the proportion of the ingredients.

By theſe means the dyes obtained from Brazil wood may be rendered conſiderably ſolid; but by no means comparable in this reſpect to thoſe afforded by

* Inſtruction ſur l'Art de Teinture.

cochineal or madder. The dye afforded by this laſt ſubſtance is ſometimes rendered brighter, by paſſing the dyed ſtuff through a decoction of Brazil; but the effect ſoon goes off.

M. Guhliche deſcribes a proceſs, which, as he affirms, is capable of affording more beautiful and more durable colours than thoſe before uſed: he directs, that vinegar, or the * aceto-citric acid, or aqua regia, be poured upon the Brazil wood, reduced into powder, or thin ſhavings or chips, until it be covered to a certain depth. This mixture muſt be well agitated, then left at reſt for twenty-four hours, and laſtly decanted, filtered, and preſerved for uſe. A vegetable acid, or ſimple water, is poured on the reſidue, and left to repoſe for a day or two, after which it is filtered; and in this manner the proceſs is continued until no more colour is given out; the wood is then black: the ſeveral liquors are to be mixed together.

The ſtuff is prepared by a weak galling with ſumach, or the white nut gall: after this it is ſlightly alumed, ſimply rinſed and immerſed wet with the following bath:

The acid ſolution of Brazil wood is taken and diluted with a certain quantity of water, depending on the quantity of goods, and the intenſity of the colour intended to be produced. It is then heated to ſuch a degree that the hand may be held in it; ſolution of tin is then poured in until it has acquired a fine colour; the bath being then agitated, the ſtuff is to be plunged in and kept immerſed for half an hour, after which time it is to be taken out and waſhed. The remaining bath will ſerve for weaker ſhades, and the ſtuff muſt not be galled for theſe light tinges.

Brazil wood is uſed for dying ſilk of a crimſon colour. This is called the falſe dye, to diſtinguiſh it from the crimſon obtained by cochineal, which is much more durable.

The ſilk muſt be boiled with twenty pounds of ſoap for every hundred of ſilk, and afterwards alumed. The aluming need not be ſo ſtrong as for the fine crimſon. It is then waſhed in a running ſtream, and immerſed into a bath, more or leſs charged with the decoction of Brazil wood, according to the intended ſhade of colour. When water containing no earthy ſalt has been made uſe of, the colour is too red to imitate crimſon. This quality however is given to the water by paſſing the ſilk through a ſlight alkaline ſolution, or by adding a little alkali to the bath. It might likewiſe be waſhed in hard water till it had obtained the required ſhade.

To make a deeper crimſon of the falſe or red brown kind, the decoction of logwood is added to the bath of Brazil wood, after the ſilk is impregnated. A

* This acid, ſo called by M. Berthollet, but diſtinguiſhed by M. Guhliche by the name of the vegetable acid ſpirit, is much uſed by this laſt chemiſt in his dying proceſſes, and is prepared as follows: He takes lemons, not rejecting even thoſe whoſe ſkin is quite rotten; pares them, ſlices them into an earthen or metallic (but not a wooden) veſſel; ſprinkles them with good vinegar, of the ſtrength which he judges to be equal to that of lemon-juice; expreſſes the juice from the lemons, expoſed to the action of a preſs in a flannel bag; and laſtly filters it through paper. In this ſtate the liquor may be employed with ſucceſs; but it has the inconvenience of becoming mouldy, and is aqueous. To remedy theſe defects, he recommends it to be purified and concentrated as follows: The liquor is left expoſed to the ſun until it has become clear and depoſited a ſediment. It is then filtered and diſtilled on a ſand bath. As ſoon as the drops which come over are perceived to be acid, the receiver is changed, and the diſtillation is continued until oily ſtriæ are perceived in the neck of the retort. The acid which is thus obtained muſt be preſerved for uſe.

ſmall

ſmall quantity of alkali is likewiſe added, according to the ſhade intended to be produced.

To imitate the wild poppy, or fiery red, the ſilk muſt firſt receive a ground of rocou (better known in England by the name of ANNOTTO, which ſee), even deeper than when the dye with carthaucus is intended; after which it is waſhed, alumed, and dyed with the decoction of Brazil wood, to which a little ſoap water is uſually added.

The ſolution of tin cannot, as M. Berthollet obſerves, be employed with the decoction of Brazil wood, for dying ſilk in the ſame manner as with cochineal, becauſe the colouring particles are too quickly ſeparated to be able to fix themſelves on the ſilk, which has not ſo ſtrong an attraction for them as wool has. But, as Bergman remarks, in his notes upon Scheffer's Eſſay on the Art of Dying, it is poſſible to make great improvement in the colours afforded by the dying woods, by macerating the ſilk in a cold ſolution of tin. A ſtrong decoction of Brazil wood gives to yellow ſilk a ſcarlet colour, inferior indeed to that of cochineal, but much more lively and ſolid than is had by mere maceration in alum, and capable of reſiſting the proof of vinegar, like the fine crimſon and poppy colours. Inſtead of uſing the raw ſilk, it is requiſite to give a yellow ground to boiled ſilk, or to mix a yellow ſubſtance with the decoction of Brazil wood. Several manufacturers have lately buſied themſelves with this proceſs, and have produced a variety of effects, by applying it to different colouring matters, which afford colours of very little ſolidity, whether they be employed alone, or in forming different mixtures.

M. Guhliche nevertheleſs deſcribes a proceſs, in which he makes an immediate uſe of the ſolution of tin, to give a fire colour to ſilk. He directs that it ſhould be galled by a ſolution of nut galls in white wine. He affirms that this ſolution preſerves much more of that brilliancy, ſo much in requeſt in the colour of ſilk, than the ſolution made in water. He adds ſuch a quantity of this ſolution to water as may give the whole a yellow colour; with this he carefully impregnates the ſilk, leaving it in the cold for twelve hours, after which he expreſſes the liquor very well, but without the action of waſhing. The ſilk being then dried is ſteeped in a ſolution of alum, in the proportion of four ounces of alum for every pound of the ſilk, where it remains for twelve hours. He then preſſes out the acid, and immerſes the ſilk, wet as it is, into a bath prepared in the way already deſcribed, after having added an ounce of the ſolution of tin. The remaining force of the bath may be exhauſted for lighter ſhades. If the fire colour be required more inclining to orange, he does not gall the ſilk, but alums it in a cold ſolution of two ounces of alum, of the ſtrength of two ounces of the ſalt for every pound of the ſilk; after which he dyes it of an orange colour with annotto, without boiling, and plunges it ſtill wet into the before-mentioned bath of Brazil wood. The author confeſſes, that theſe colours, more eſpecially the laſt, do not poſſeſs much ſolidity. For roſe colours he omits the galling, and uſes no more than two ounces of alum. For light ſhades he recommends to decant the ſolution of alum from the depoſition it may have made; and he prefers dying without heat, by employing a bath more highly charged with colour, out of which the ſilk may be taken when it has received the intended ſhade, and which may be afterwards exhauſted in producing other ſhades. He affirms that, by the aſſiſtance of theſe precautions, beautiful ſhades may be obtained of ſufficient ſolidity.

M. Poerner has made a great number of eſſays on the methods which may be uſed to dye cotton by means of Brazil wood, with different mordants, ſuch as alum, the ſolution of tin, ſal ammoniac, alkali, &c. either in the bath or in the pre-

paration of the ſtuff; but he could not produce colours capable of reſiſting the action of ſoap, though ſeveral among them withſtood the action of the air, and waſhing in water. He adviſes that the cottons dyed with theſe colours ſhould be dried in the ſhade.

The following proceſs, uſed in ſome manufactories for dying cotton of a crimſon colour, was communicated to M. Berthollet by Mr. Brown.

A ſolution of tin is made in theſe proportions of the ingredients: nitrous acid two pounds, muriatic acid one pound, tin eight ounces, water one pound: the fluids are to be mixed, and the tin diſſolved in the mixture by adding a little at a time.

For a piece of cotton velvet, weighing fifteen or ſixteen pounds, the operation is begun by preparing a bath compoſed of four parts boiling water, and two parts of a ſtrong decoction of nut-galls. The bath is then ſtirred with the rake, the piece plunged in it worked for half an hour, left immerſed for two hours, and afterwards taken out and drained. Another bath is alſo prepared with three parts of boiling water, and one of the decoction of Brazil wood likewiſe boiling; this is raked, and the piece worked in it for half an hour. The liquor is then thrown out, and the vat filled with a decoction of Brazil wood, unmixed and boiling. In this the piece is worked for half an hour, and then lifted out on a croſs. A bath of very clear river water is then prepared, in which a pint of ſolution of tin is poured; and when the bath has been well raked, and the piece worked for half an hour, it is taken out on the croſs, and carried to the bath of the decoction of Brazil wood, out of which one ſixth part of the whole has been taken, and replaced with an equal quantity of the boiling decoction. In this bath the piece is worked for half an hour, then raiſed on the croſs, and returned to the bath, which contains the ſolution of tin. Theſe alternate operations are repeated ſix or eight times; taking care every time to take out one ſixth of the bath of the Brazil or Fernambouc wood, and to replace it with an equal quantity of the boiling decoction of the ſame wood, to rake or ſtir the bath of the compoſition every time, and to finiſh the dye by the piece remaining in the latter bath. The piece is laſt of all to be waſhed in plenty of water, or a ſtream, and it muſt be dried in a place inacceſſible to the light.

The colouring particles of Brazil wood are eaſily affected and rendered yellow by acids, after which change they become ſolid colours. But what diſtinguiſhes them from madder and kermes, and indicates a reſemblance to cochineal, is that they appear again in their original colour, when precipitated with alum, or the calx of tin. Theſe two combinations appear the moſt proper to render the colour durable. It is neceſſary, therefore, to enquire after and aſcertain the circumſtances moſt proper to favour their combinations, according to the nature of the ſtuff.

The aſtringent principle likewiſe appears to contribute to the ſolidity of the colouring parts of Brazil wood: but this galling renders the colour deeper, and cannot be uſed for light ſhades.

The colouring parts of Brazil wood are very ſenſible to the action of alkalis, which give them a purple tinge; and there are many proceſſes in which fixed or volatile alkalis are uſed to form violets and purples: but the colours, though obtained with eaſe in various ſhades by this method, are periſhable, and poſſeſs only a tranſient brightneſs. Alkalis do not appear to injure the colours afforded by madder, but they haſten the deſtruction of moſt other colours.

It is uſual in England to raſp or pulverize the dying woods in mills appropriated to that purpoſe. They are commonly kept moiſtened with urine; and when urine has not been uſed, a ſmall quantity of alkali is added at the time of boiling.

boiling. This method of proceeding, as M. Berthollet obſerves, is very advantageous; but the uſe of putrefied urine, or alkali, tends to deepen the colour, to render it leſs permanent, and may, on various occaſions, be contrary to the nature of the proceſſes intended to afford certain effects.

BREAD. I am not acquainted with any ſet of experiments regularly inſtituted and carried into effect, for aſcertaining what happens in the preparation of bread. Farinaceous vegetables are converted into meal by trituration, or grinding in a mill; and when the huſk or bran has been ſeparated by ſifting or bolting, the powder is called flour. This is compoſed of a ſmall quantity of mucilaginous ſaccharine matter, ſoluble in cold water, much ſtarch, which is ſcarcely ſoluble in cold water, but combines with that fluid by heat, and an adheſive grey ſubſtance inſoluble in water, ardent ſpirit, oil, or ether, and reſembling an animal ſubſtance in many of its properties. *See* FARINA, STARCH, GLUTEN VEGETABLE, MUCILAGE.

When flour is kneaded together with water, it forms a tough paſte, containing theſe principles very little altered, and not eaſily digeſted by the ſtomach. The action of heat produces a conſiderable change in the gluten, and probably in the ſtarch, rendering the compound more eaſy to maſticate, as well as to digeſt. Hence the firſt approaches towards the making of bread conſiſted in parching the corn, either for immediate uſe as food, or previous to its trituration into meal; or elſe in baking the flour into unleavened bread, or boiling it into maſſes more or leſs conſiſtent; of all which we have ſufficient indications in the hiſtories of the earlier nations, as well as in the various practices of the moderns. It appears likewiſe from the Scriptures, that the practice of making leavened bread is of very conſiderable antiquity; but the addition of yeaſt, or the vinous ferment, now ſo generally uſed, ſeems to be of modern date.

Unleavened bread in the form of ſmall cakes, or biſcuit, is made for the uſe of ſhipping in large quantities; but moſt of the bread uſed on ſhore is made to undergo, previous to baking, a kind of ferment, which appears to be of the ſame nature as the fermentation of ſaccharine ſubſtances; but is checked and modified by ſo many circumſtances as to render it not a little difficult to ſpeak with certainty and preciſion reſpecting it.

When dough or paſte is left to undergo a ſpontaneous decompoſition in an open veſſel, the various parts of the maſs are differently affected, according to the humidity, the thickneſs, or thinneſs of the part, the vicinity or remoteneſs of fire, and other circumſtances leſs eaſily inveſtigated. The ſaccharine part is diſpoſed to become converted into ardent ſpirit, the mucilage has a tendency to become ſour and mouldy, while the gluten in all probability verges toward the putrid ſtate. An entire change in the chemical attractions of the ſeveral component parts muſt then take place in a progreſſive manner, not altogether the ſame in the internal and more humid parts as in the external parts, which not only become dry by ſimple evaporation, but are acted upon by the ſurrounding air. The outſide may therefore become mouldy or putrid, while the inner part may be only advanced to an acid ſtate. Occaſional admixture of the maſs would of courſe not only produce ſome change in the rapidity of this alteration, but likewiſe render it more uniform throughout the whole. The effect of this commencing fermentation is found to be, that the maſs is rendered more digeſtible and light; by which laſt expreſſion it is underſtood, that it is rendered much more porous by the diſengagement of elaſtic fluid, that ſeparates its parts from each other, and greatly increaſes its bulk. The operation of baking puts a ſtop to this proceſs,

ceſs, by evaporating great part of the moiſture which is requiſite to favour the chemical attraction, and probably alſo by ſtill farther changing the nature of the component parts. It is then bread.

Bread made according to the preceding method will not poſſeſs the uniformity which is requiſite; becauſe ſome parts may be mouldy, while others are not yet ſufficiently changed from the ſtate of dough. The ſame means are uſed in this caſe as have been found effectual in promoting the uniform fermentation of large maſſes. This conſiſts in the uſe of a leaven or ferment, which is a ſmall portion of ſome matter of the ſame kind, but in a more advanced ſtage of the fermentation. After the leaven has been well incorporated by kneading into freſh dough, it not only brings on the fermentation with greater ſpeed, but cauſes it to take place in the whole of the maſs at the ſame time: and as ſoon as the dough has by this means acquired a due increaſe of bulk from the fixed air, which endeavours to eſcape, it is judged to be ſufficiently fermented, and ready for the oven.

The fermentation, by means of leaven or ſour dough, is thought to be of the acetous kind, becauſe it is generally ſo managed that the bread has a ſour flavour and taſte. But it has not been aſcertained that this acidity proceeds from true vinegar. Bread raiſed by leaven is uſually made of a mixture of wheat and rye, not very accurately cleared of the bran. It is diſtinguiſhed by the name of brown bread; and the mixture of theſe two kinds of grain is called bread-corn in many parts of the kingdom, where it is raiſed on one and the ſame piece of ground, and paſſes through all the proceſſes of reaping, threſhing, grinding, &c. in this mixed ſtate.

Yeaſt or barm is uſed as the ferment for the finer kinds of bread. This is the mucilaginous froth which riſes to the ſurface of beer in its firſt ſtage of fermentation. When it is mixed with dough, it produces a much more ſpeedy and effectual fermentation than that obtained by leaven, and the bread is accordingly much lighter, and ſcarcely ever ſour. The fermentation by yeaſt ſeems to be almoſt certainly of the vinous or ſpirituous kind.

Bread is much more uniformly miſcible with water than dough, and on this circumſtance its good qualities moſt probably do in a great meaſure depend.

A very great number of proceſſes are uſed by cooks, confectioners, and others, to make cakes, puddings, and other kinds of bread in which different qualities are required. Some cakes are rendered brittle, or as it is called *ſhort*, by an admixture of ſugar or of ſtarch. Another kind of brittleneſs is given by the addition of butter or fat. White of egg, gum-water, iſinglaſs, and other adheſive ſubſtances are uſed, when it is intended that the effect of fermentation ſhall expand the dough into an exceedingly porous maſs. The reflecting chemiſt will receive conſiderable information on this ſubject from an attentive inſpection of the receipts to be met with in treatiſes of cooking and confectionary.

BRECCIA. An Italian term frequently uſed by our mineralogical writers, to denote ſuch compound ſtones as are compoſed of agglutinated fragments of conſiderable ſize. When the agglutinated parts are rounded, the ſtone is called pudding-ſtone. Breccias are denominated according to the nature of their component parts. Thus we have calcareous breccias, or marbles, and ſiliceous breccias, which are ſtill more minutely claſſed, according to their varieties. See the Mineralogies of Cronſtedt, Kirwan, and others.

BRICK. Among the numerous branches of the general art of faſhioning argillaceous earths into uſeful forms, and afterwards hardening it by fire, the art of making

making bricks and tiles is by no means one of the leaſt uſeful. By this art we poſſeſs the advantage of obtaining the materials for conſtructing edifices at cheap rates, in almoſt every ſituation, without the expence of carrying ſtone from remote quarries; and this is ſo far from being the only advantage, that it is extremely probable that theſe artificial compoſitions, if properly made, would prove ſuperior in durability to every natural ſtone. The ſtreets in Holland are every where paved with a hard kind of brick, known by us under the name of clinkers, and uſed in this country for paving ſtables and court-yards; and the houſes in Amſterdam appear to be not at all decayed, but were perfectly freſh, as if new, though moſt of thoſe in the vicinity of the Exchange have ſtood at leaſt two centuries. The ſpirit of improvement may perhaps effect at ſome future period, in this country, what the ſtimulus of neceſſity has done on that naturally poor ſpot.

The art of brickmaking has for the moſt part been confined to the manufactories, no one having attended to it in a direct chemical way, except the celebrated Bergman. I ſhall therefore in the preſent article give an account of the leading facts and obſervations in his treatiſe*.

The pottery made uſe of in the conſtruction of edifices may be conſidered as of two forms; tiles for the roof, or bricks for the walls; to which may be added another kind of bricks for pavements. Softneſs and poroſity are the greateſt fault of tiles. The water retained in the pores of tiles becomes frozen in winter; and as ice occupies a larger ſpace than water, the expanſion of the water, at the inſtant of its congelation, does not fail to ſplit and deſtroy ſuch porous and brittle ſubſtances as tiles which are ill made. This has been remedied by covering them with a glaze, which adds conſiderably to the expence. Bergman is of opinion that a ſtronger heat uſed in the baking would render them ſo cloſe as to abſorb very little moiſture.

This illuſtrious chemiſt did not find that pure clay, or argillaceous earth, was fuſible either alone or when mixed in any proportion with lime, though the addition of the ſmalleſt quantity of ſiliceous earth brought the maſs into fuſion. Neither was clay fuſible with pure quartz alone. Fluor mineral renders it fuſible as does likewiſe feld ſpar.

Common clay is ſcarcely ever found in a ſtate approaching to purity on the ſurface of the earth. It uſually contains a large proportion of ſiliceous earth. Bergman examined ſeveral clays in the neighbourhood of Upſal, and made bricks, which he baked with various degrees of heat, ſuffered them to cool, immerſed them in water for a conſiderable time, and then expoſed them to the open air for three years. They were formed of clay and ſand. The hardeſt were thoſe, into the compoſition of which a fourth part of ſand had entered. Thoſe which had been expoſed for the ſhorteſt time to the fire were almoſt totally deſtroyed, and crumbled down by the action of the air: ſuch as had been more thoroughly burned, ſuffered leſs damage; and in thoſe which had been formed of clay alone, and were half vitrified by the heat, no change whatever was produced.

On the whole, he obſerves, that the proportion of ſand to be uſed to any clay, in making bricks, muſt be greater, the more ſuch clay is found to contract in burning; but that the beſt clays are thoſe which need no ſand. Bricks ſhould be well burned; but no vitrification is neceſſary when they can be rendered hard enough by the mere action of the heat. Where a vitreous cruſt might be deemed neceſſary, he recommends the projection of a due quantity of ſalt into

* Phyſical and Chemical Eſſays, vol. iii. p. 378.

the furnace, which would produce the effect in the ſame manner as i ſeen in the fabrication of the Engliſh pottery, called ſtone ware.

It is of conſiderable importance to examine clay before it is made into tiles. This is done in a rough way by the manufacturers; but Bergman adviſes the following as the moſt expeditious proceſs: Nitrous acid poured upon unburned clay detects the preſence of lime, by producing an effervescence. Calcareous clays, or marles, are often the fitteſt materials for making bricks. In the next place, a lump of clay, of a given weight, is to be diffuſed in water by agitation. The ſand will ſubſide, and the clay remain ſuſpended. Other waſhings of the reſidue will carry off ſome clay, and, by due management in this way, the ſand, or quartzoſe matter, may be had ſeparate. Nitrous acid by digeſtion will take up the lime from a part of the clay, previouſly weighed, and this may be precipitated by volatile alkali. The clay, the ſand, and the lime may thus be well enough aſcertained by weight, ſo as to indicate the quantity of ſand or other material requiſite to be added in order to form that compound, which, from other experiments, may have been found beſt adapted to produce good tiles and bricks. An examination with the microſcope will ſhew whether the ſand contain feld, ſpar, or other ſtones of known figure.

The brickmakers in the vicinity of London collect the refuſe cinders and aſhes of the coal fires of that metropolis, and employ women to ſift them. The cinders are uſed as fuel in the burning, and the ſmaller powder, or black aſhes, enter into the compoſition of the bricks inſtead of ſand.

BRIMSTONE. *See* SULPHUR.

BROCATELLO. A calcareous ſtone or marble, compoſed of fragments of four colours, white, grey, yellow, and red.

BRONZE. A mixed metal conſiſting chiefly of copper, with a ſmall proportion of tin, and ſometimes other metals. It is uſed for caſting ſtatues, cannon, bells, and other articles, in all which the proportions of the ingredients vary. The addition of tin to copper renders it brittle and hard, ſingularly augments its denſity, and makes it more fuſible. The compound poſſeſſes likewiſe the advantage of being leſs ſubject to corroſion, or ruſt, by expoſure to the air. Cannon and ſtatues have leſs tin in their compoſition than bells; and in ſpeculum metal the proportion is greateſt of all. *See* SPECULUM.

The operation by which large works of bronze are caſt, as deſcribed by Macquer, is ſufficiently ſimple. For this purpoſe a brick furnace is uſed, nearly in the ſhape of a baker's oven. The floor of this furnace is concave, and conſiſts of a compoſition of ſand and clay. In this hollow floor the metals are put. The furnace has four openings.

The firſt is a lateral mouth, at which the flame of the fuel enters, which is placed in a ſecond furnace on one ſide the firſt. The ſecond opening is a chimney placed on the ſide oppoſite the mouth, by means of which the flame is drawn over the metal. The third opening is a hole, which can be ſhut or opened at pleaſure, to inſpect the ſtate of the inſide of the furnace and its contents. When the metal is in the ſtate required, a fourth opening is then incloſed, communicating with the hollow floor, through which the melted metal flows by channels into the moulds prepared to receive it.

The recovery of copper from old bell metal is an object which is ſometimes deſirable. Chemiſtry affords various methods of doing this, an intereſting detail of which may be ſeen in the ninth volume of the Annales de Chimie.

BUTTER. The oily inflammable part of milk, which is prepared in many countries as an article of food. This ſubſtance appears to be diffuſed through milk, either mechanically, or, which is more probable, by an imperfect chemical union; that is, by combination with the caſeous, ſaccharine, and acid parts, which form the medium of its ſuſpenſion in the aqueous fluid. When milk is ſuffered to remain at reſt for ſeveral hours, a thick fluid riſes to the top, well known by the name of cream, and conſiſting of the butter, together with a conſiderable maſs of caſeous and ſerous particles. It has not been aſcertained whether this aſcent of the cream be attended with any chemical change or ferment of the whole fluid; but it ſeems very probable that this is the caſe.

Butter as it exiſts in cream does not form continued maſſes, but has its parts ſeparated by the interpoſition of the other principles. Some butter will however be ſeparated without any operation, farther than the mere continuance of ſtanding undiſturbed. But the common method of ſeparating it conſiſts in agitating the cream, for a certain time, in a veſſel called a churn, the form of which is various, but its eſſential purpoſe the ſame. By this treatment it is collected in an uniform ſoft maſs, poſſeſſing ſcarcely any ſmell; of a mild agreeable taſte, eaſily fuſible, and ſuffering no perceptible diſengagement of any of its principles by any degree of heat not exceeding that of boiling water.

We do not poſſeſs any direct experiments to ſhew what it is that occaſions the difference between the obvious qualities of butter and thoſe of other oils, diſtinguiſhed by the name of fat or fixed oils, from their not riſing by a low heat. It reſembles them in its habitudes as nearly as they reſemble each other reſpectively. By diſtillation on the water bath it gives out a portion of watery fluid, that either remained interpoſed between its parts from the firſt, or was taken up during the waſhing it undergoes in the making. A ſtronger heat, carefully managed, expels firſt a ſtrong acid of a penetrating ſmell, which is followed by a concrete coloured oil poſſeſſing the ſame odour. Very little coal remains. The acid appears to be of the ſame nature as that diſtinguiſhed by the name of the acid of fat: and it may alſo be obtained from butter by means of lime or an alkali. *See* ACID OF FAT.

Butter becomes rancid ſooner than moſt other fat oils, probably on account of the water, which may favour the developement of its acid. Waſhing with water or ardent ſpirit reſtores it in ſome meaſure to its former ſtate, by carrying off the diſengaged part of the acid. Fixed alkalis diſſolve butter, and form ſoap.

BUTTER OF ANTIMONY. The combination of the regulus of antimony with the dephlogiſticated or aerated marine acid. It is uſually made by diſtilling a mixture of corroſive ſublimate and the regulus. *See* ANTIMONY.

BUTTER OF ARSENIC. A combination of the regulus of arſenic with dephlogiſticated or aerated marine acid; obtained by a proceſs ſimilar to that uſed in making the butter of antimony.

BUTTER OF CACAO. An oily concrete white matter, of a firmer conſiſtence than ſuet, obtained from the cacao nut, of which chocolate is made. The method of ſeparating it conſiſts in bruiſing the cacao and boiling it in water. The greateſt part of the ſuperabundant and uncombined oil contained in the nut is by this means liquefied, and riſes to the ſurface; where it ſwims, and is left to congeal, that it may be the more eaſily taken off. It is generally mixed with ſmall pieces of the nut, from which it may be purified by keeping it in fuſion without water in a pretty deep veſſel, until the ſeveral matters have arranged

themſelves according to their ſpecific gravities. By this treatment it becomes very pure and white.

Butter of cacao is without ſmell, and has a very mild taſte, when freſh; and in all its general properties and habitudes it reſembles fat oils; among which it muſt therefore be claſſed. It is uſed as an ingredient in pomatums.

BUTTER OF WAX. Wax, though differing very conſiderably from fat oils, reſembles them in affording an acid by diſtillation, while the remaining oleaginous part becomes more limpid, in proportion as the number of diſtillations is repeated. The firſt diſtillation leaves it of a butyraceous conſiſtence, and this is called butter of wax. It has a ſtrong ſmell, and is ſaid by Macquer not to recover its conſiſtence by long expoſure to the air; in which particular he obſerves that it differs from reſinous ſubſtances.

BUTTER OF TIN. When granulated tin, or an amalgam of tin and mercury, is diſtilled with corroſive ſublimate, the tin riſes in combination with the dephlogiſticated or aerated marine acid, partly in the form of a liquor and partly in butyraceous flowers. The liquor is called the fuming liquor of Libavius, and is not eſſentially different from the flowers. Many chemiſts diſtinguiſh the whole product by the name of the fuming liquor of Libavius. *See* TIN.

BUTTON. The round maſs of metal obtained in ſmall reductions or other chemical experiments, and found at the bottom of the crucible or veſſel wherein the operation is performed, is called the button by chemiſts.

BYSSUS. The aſbeſtus, compoſed of parallel fibres, is diſtinguiſhed by ſome under this name.

C.

CAB CAD

CABOCHON. The French uſe this word to denote the figure of precious ſtones when poliſhed with a convex ſurface.

CACHOLONG. A very hard compact white agate. It is ſemi-tranſparent, and in this reſpect differs from the moonſtone, which has a milky white, with a few various ſhades of light proceeding from an internal blueiſh ground. The cacholong is vitrifiable and capable of a good poliſh. It is found in the river Cache in the Calmucks' country, whence in their language it takes its name.

CADMIA. A word ſcarcely met with in the writings of the later chemiſts. It has been given to various ſubſtances. The cadmia of the furnaces is a matter that ſublimes when ores containing zinc, like thoſe of Rammelſburg, are ſmelted. This conſiſts of the flowers of zinc, which riſe by the violent heat of combuſtion, and adhere to the inſide of the walls of the furnace; which being hot do not condenſe them immediately into the ſolid ſtate, but cauſe them to paſs through a ſtate of fluidity intermediate between the elaſtic and the ſolid ſtate. On this account they have a much leſs interrupted ſolidity than the flowers of zinc uſually poſſeſs. The quantity collected at Rammelſburg is ſo conſiderable as

to form a very thick cruſt, requiring to be frequently removed. The name of cadmia has alſo been given to other ſublimates that riſe in the ſmelting of ores.

Calamine, or lapis calaminaris, which is an ore of zinc, has alſo been called native cadmia. This, as well as the cadmia of the furnaces, is uſed in the converting copper into braſs. *See* COPPER.

The ore of cobalt is ſometimes, but very improperly, called foſſil cadmia.

CÆRULEUM MONTANUM. An ore of copper claſſed by Cronſtedt among the calcareous earths, as a combination of that earth with the metal. Kirwan, however, aſſerts poſitively that 100 parts contain about 69 of copper, 29 of aerial acid or fixed air, and 2 of water. It is moſt frequently found of a looſe pulverulent form, though ſometimes indurated and even cryſtallized, but it is then mixed with quartz. It may be analyſed by ſolution in acids, and precipitation by immerſing a piece of iron in the ſolution, which will throw down the copper in the metallic ſtate.

CALAMINE. An ore of zinc of a white, grey, yellow, brown, or red colour, of various hardneſs, though ſcarcely ever hard enough to ſtrike fire with the ſteel. Its texture is either equable or cellular, and its form irregular, or cryſtallized, or in ſtalactites. It does not loſe weight by calcination, unleſs mixed with charcoal; and then the zinc riſes in flowers. Acids diſſolve it, and with the vitriolic it affords vitriol of iron as well as of zinc. The ſpecific gravity of the beſt ſort, that is the grey, is 5,000, and 100 parts of this afforded Bergman 84 of calx of zinc, 3 iron, 1 clay, and 12 ſiliceous earth; but in other ſpecimens the proportions are very different. Moſt of the Engliſh calamines contain lead.

CALCAREOUS EARTH. *See* EARTHS.

CALCES, METALLIC. Metals which have undergone the proceſs of calcination or combuſtion, or any other equivalent operation.

CALCINATION. The fixed reſidues of ſuch matters as have undergone combuſtion are called cinders in common language, and calces by chemiſts; and the operation, when conſidered with regard to theſe reſidues, is termed calcination. In this general way it has likewiſe been applied to bodies not really combuſtible, but only deprived of ſome of their principles by heat. Thus we hear of the calcination of chalk, to convert it into lime, by driving off its fixed air and water; of gypſum or plaſter ſtone, of alum, of borax, and other ſaline bodies, by which they are deprived of their water of cryſtallization; of bones, which loſe their volatile parts by this treatment; and of various other bodies.

This application of the term is nevertheleſs at preſent avoided by chemiſts, who in general conſider it as improper, and confine the term to the only claſs of bodies truly combuſtible, which leave a large fixed reſidue after combuſtion; namely, metals.

When a metallic ſubſtance is expoſed to a conſiderable heat with acceſs of reſpirable air, its external part becomes gradually converted into a calx of a dull earthy appearance, leſs fuſible, and of a leſs ſpecific gravity, than the metal itſelf, brittle or friable when cold, and weighing upon the whole more than the regulus which afforded it. The metals called perfect are not calcinable by the heat of common furnaces; and among the ſemi-metals there are ſome whoſe calces are conſiderably volatile, and riſe in the form of flowers. *See* METALS, and alſo the reſpective articles of each.

The calcination of metals is indubitably an effect of the ſame nature as other combuſtions, and is conſidered as ſuch by all chemiſts. But as the theories of

combuſtion differ, the explanations muſt vary accordingly. In the ancient theory of Stahl, metals, like other combuſtible bodies, were conſidered as compounds of one general principle of inflammability, united to a particular baſis in each. This principle, called phlogiſton, was ſuppoſed to be driven off during combuſtion, and to leave the bare or metallic calx behind it. Various hypotheſes were propoſed to account for the increaſed weight of the calces, which was firſt truly accounted for by Mayow, who aſcribed it to the abſorption of air. When modern diſcoveries had re-eſtabliſhed this truth, that the reſpirable part of the air is abſorbed in combuſtion, the adherents of Stahl found it neceſſary to modify their doctrine by attributing the extrication of phlogiſton to an effect of affinity. In this way the inflammable principle was ſaid to be expelled by the ſtronger affinity of the air to the calx, at the temperature of the experiment; or otherwiſe, admitting the matter of heat to have a ſeparate exiſtence, it was ſuppoſed to quit the elaſtic fluid air, at the time of its condenſation, and unite with the phlogiſton, which was affirmed to make its eſcape in the flame.

The modern theory of the antiphlogiſtians, rejecting altogether the exiſtence of a principle of inflammability, aſcribes the whole effect to the air which enters into combination. In this a metal is a ſimple ſubſtance, and a calx is a metal united to a portion of vital air.

The calcination of metals is effected by the mere acceſs of the vital air of the atmoſphere, provided the temperature be raiſed to a ſufficient height. Nitre greatly accelerates this effect, becauſe it affords vital air by the decompoſition of its acid when duly heated. The acids likewiſe calcine metals without, in general, requiring any external application of heat. Nitrous acid, being more readily decompoſed than any other, is accordingly more active in the calcination of metals. In this proceſs the vital air of the acid unites with (and perhaps dephlogiſticates) the metal, while the other part of the acid, namely the phlogiſticated air, flies off, either alone or in the form of nitrous air. The calx is either diſſolved or precipitated, accordingly as it contains a leſs or greater quantity of vital air; this ſubſtance appearing to be the medium of ſuſpenſion, to which the calx has no tendency if completely ſaturated.

When vitriolic acid is employed in the calcination and ſolution of a metal, the part of the acid which flies off is ſulphur, more or leſs acidified, in the form of ſulphureous or volatile vitriolic acid. *See* HEAT, PHLOGISTON, METALS, ACIDS, COMBUSTION.

CALX, METALLIC. *See* CALCES, *alſo* CALCINATION.

CALL. A word uſed by the miners to denote ſchoerl or cockle, and alſo other matters; but Da Coſta ſays that, definitely ſpeaking, it denotes the mineral called wolfram.

CAMELEON MINERAL. The combination of fixed alkali and calx of manganeſe has been ſo called, on account of the changes of colour it is ſubject to when diſſolved in water.

CAMOMILE. A ſmall quantity of blue eſſential oil reſides in the cup of the flowers. This colour changes to a browniſh green by age, and that more readily in half filled or imperfectly cloſed veſſels than in ſuch as are entirely full. Camomile flowers boiled in wine give it a manifeſtly ſaline taſte, and the decoction precipitates ſilver and mercury from nitrous acid. But as the precipitates were different from thoſe afforded by common ſalt, Neumann, from whom this article is taken, is juſtly of opinion that the precipitating ſalt was afforded by the wine.

Sir

Sir John Pringle finds, by his experiments, that the ſoluble part of camomile flowers is one hundred and twenty times as antiſeptic as common ſalt.

CAMPAN MARBLE. The green campan from the Pyrenean mountains is ſlightly magnetic, and contains, according to Mr. Bayen, in the centenary ſixty-five parts mild calcareous earth, thirty-two argillaceous, and three of iron partially calcined. The red campan is not magnetic, and contains eighty-two parts mild calcareous earth, eleven of argillaceous earth, and ſeven of calx of iron.

CAMPHOR. This ſingular vegetable ſubſtance comes to us from China. There are two kinds grow in the Eaſt, the one produced in the iſlands Sumatra and Borneo, and the other produced in Japan and China. The Sumatran camphor, which the Europeans obtain, is carried to the China market, where it bears a better price than the Japaneſe. This has given riſe to an opinion, that the Chineſe buy it to convert it, by ſome manipulation, into the other. The properties of the camphor we receive render this in the higheſt degree improbable.

Camphor* is extracted from the roots, wood, and leaves of a large tree, the roots affording by far the greateſt abundance. The method conſiſts in diſtilling with water in large iron pots, ſerving as the body of a ſtill, with earthen heads adapted, ſtuffed with ſtraw, and provided with receivers. Moſt of the camphor becomes condenſed in the ſolid form among the ſtraw, and part comes over with the water. It is ſaid by ſome to be ſublimed without water; but Neumann thinks, perhaps without foundation, that ſuch treatment would give an empyreumatic ſmell to the camphor. The rough camphor, as imported, reſembles crude nitre or bay ſalt. It is imported in caniſters.

The refining of camphor was long a ſecret with the Venetians, at the time when moſt of the commodities of the Eaſt were brought into Europe by that people. The Hollanders have ſince appropriated to themſelves this, with various other manufactures dependent on chemiſtry; and I do not find that it is purified in large quantities elſewhere. Neumann mentions one of the largeſt refineries at Amſterdam, in which were fifty furnaces, all managed by women. He was permitted to ſee the whole operation, except the charging of the veſſels. The ſublimation was performed in low flat-bottomed glaſs veſſels placed in ſand; and the camphor became concrete in a pure ſtate againſt the upper part, whence it was afterwards ſeparated with a knife after breaking the glaſs. Lewis, in a note on this paſſage, aſſerts, that no addition is requiſite in the purification of camphor; but that the chief point conſiſts in managing the fire ſo that the upper part of the veſſel may be hot enough to bake the ſublimate together into a kind of cake. He thinks it more commodious to diſſolve the crude camphor in ardent ſpirit, and, after decantation or filtration, to diſtil off the ſpirit, and fuſe the camphor into a cake in a glaſs veſſel. Chaptal ſays the Hollanders mix an ounce of quicklime with every pound of camphor previous to the diſtillation.

Purified camphor is a white concrete cryſtalline ſubſtance, not brittle, but eaſily crumbled, having a peculiar conſiſtence reſembling that of ſpermaceti, but harder. It has a ſtrong lively ſmell, and an acrid taſte; is ſo volatile as totally to exhale when left expoſed in a warm air; is light enough to ſwim on water; and is very inflammable, burning with a very white flame and ſmoke, without any reſidue.

The roots of zedoary, thyme, roſemary, ſage, the inula helenium, the anemony, the paſque flower or pulſatilla, and other vegetables, afford camphor by diſ-

* Neumann by Lewis, ii. 59.

tillation,

tillation. It is obſervable, that all theſe plants afford a much larger quantity of camphor, when the ſap has been ſuffered to paſs to the concrete ſtate by ſeveral months drying. Thyme and peppermint, ſlowly dried, afford much camphor; and M. Achard has obſerved, that a ſmell of camphor is diſengaged when volatile oil of fennel is treated with acids. The combination of diluted nitrous acid with the volatile oil of aniſe afforded him a large quantity of cryſtals, that poſſeſſed moſt of the properties of camphor; and he obtained a ſimilar precipitate by pouring the vegetable alkali upon vinegar ſaturated with the volatile oil of angelica.

From all theſe facts Chaptal concludes that the baſe of camphor forms one of the conſtituent parts of ſome volatile oils, in which it exiſts in the liquid ſtate, and does not become concrete but by combining with vital air.

Camphor is not ſoluble in water in any perceptible degree, though it communicates its ſmell to that fluid, and may be burned as it floats on its ſurface. It has been obſerved by Romieu, that ſmall pieces of camphor floating on water have a rotatory motion, which he aſcribes to electricity. Ardent ſpirit, ethers and oils, diſſolve camphor very plentifully. The former of theſe diſſolves much more by heat, though when cold it takes up three-fourths of its own weight. The ſurplus taken up by heat is ſeparated, in cryſtals of a plumoſe form, by cooling.

Nitrous acid, which acts ſo violently on eſſential oils as to cauſe inflammation, diſſolves camphor without producing heat or agitation. The camphor becomes fluid, and floats on the ſurface of the acid like oil, and has been called oil of camphor. Neumann ſays, it combines with the moſt concentrated part of the acid. The vitriolic acid unites alſo with camphor, forming a coloured fluid, which at length becomes of a dark reddiſh brown colour. Other acids alſo diſſolve it. Alkalis precipitate it heavier, harder, and much leſs combuſtible.

The addition of water to the ſpirituous or acid ſolutions of camphor inſtantly ſeparates it.

Camphor may be powdered by moiſtening it with ſpirit of wine, and triturating it till dry. It may be formed into an emulſion by previous grinding with near three times its weight of almonds, and afterwards gradually adding the water. Yolk of egg and mucilages are alſo effectual for this purpoſe; but ſugar does not anſwer well.

When nitrous acid is diſtilled repeatedly in large quantities from camphor, it converts it into a peculiar acid. M. Koſegarten diſtilled this acid eight times from it, and obtained a ſalt in parallelopipedons, which reddened ſyrup of violets and the tincture of turnſole. Its taſte is bitter, and it differs from the acid of ſugar more particularly in not precipitating lime from marine acid.

This acid forms, with vegetable alkali, a ſalt in hexagonal cryſtals; with mineral alkali, irregular cryſtals; with volatile alkali, needle-formed and priſmatic cryſtals; and with magneſia, a white pulverulent ſalt. It diſſolves copper, iron, biſmuth, zinc, arſenic, and cobalt. The ſolution of iron affords a yellowiſh white inſoluble powder. With manganeſe it forms cryſtals with parallel ſides, ſomewhat reſembling baſaltes.

CANNEL COAL. A coal which burns with a white flame, much ſmoke, and a ſmell reſembling pitch. It probably owes its name to its uſe as a ſubſtitute for candles in many of the poorer families in the north of England, who in their ſtore of coals take care to be provided with a ſeparate portion of this to be laid on the fire at night. Kirwan ſays that it breaks eaſily in any direction, and

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in its fracture preſents a ſmooth conchoidal ſurface, if broken tranſverſely. Its ſpecific gravity is about 1. 27.

CANTHARIDES. A well known fly with green wings, very common in hot countries, and much uſed as an article of the materia medica. The powder of this inſect applied to the ſkin cauſes bliſters, excites urine, thirſt, and fever. They produce the ſame effect when taken in a ſmall doſe internally. Larger doſes have occaſioned priapiſms, with loſs of blood, and laſtly death. The ignorant have formerly adminiſtered this ingredient to excite venereal emotions, but never without much danger.

M. Thouvenel has made ſome valuable experiments on cantharides. Water extracts a very abundant principle, which gives it a reddiſh yellow colour, and alſo ſeparates a yellowiſh oily principle. Ether takes up a greeniſh very acrid oil, wherein the virtue of the cantharides moſt eminently reſides. An ounce of cantharides afforded,

Reddiſh yellow bitter extract, - - -	216 grains.
Yellow oily matter, - - -	12
Green oily ſubſtance analogous to wax, - -	60
Parenchyma, ſoluble neither in water nor ardent ſpirit,	288
The French ounce,	576

Proof ſpirit, or a mixture of equal parts of water and ſtrong ardent ſpirit, extracts, by digeſtion, a tincture from cantharides which poſſeſſes all the virtues of the inſects themſelves. When this tincture is diſtilled, the ſpirit which comes over has the ſmell of the cantharides.

Strong ardent ſpirit takes up the cauſtic part only; whence it follows that the intenſity of the tincture may be varied, as well by varying the ſtrength as the quantity of the ſpirit to a given doſe of the inſects. This tincture has the character of warming and increaſing the circulation of the parts to which it may be applied in rheumatic pains, ſciatica, the wandering gout, &c.

Neumann was acquainted with the reſinous ſubſtance of cantharides, and that the virtue of this medicament reſided in it.

CAP. The piece which terminates the top of a melting furnace is called the cap. It has the figure of an oblong dome, with a large oval door on one ſide for the introduction of fuel, of which this furnace requires a quick and large ſupply. The upper part terminates in a tube or chimney, which may be lengthened accordingly as a greater or leſs draught is required.

CAPACITY. *See* HEAT.

CAPITAL. The upper part of an alembic, likewiſe called the head. *See* APPARATUS.

CAPUT MORTUUM. A fanciful term much uſed by the old chemiſts, but now entirely rejected. It denoted the fixed reſidue of operations. As the earlier chemiſts did not examine theſe, they did not find any inconvenience in one general term to denote them; but the moſt ſlender acquaintance with modern chemiſtry muſt ſhew that it is utterly impracticable to denote, by one general term, all the various matters that remain fixed in certain degrees of heat.

CARBUNCLE. The ancients called all red gems by this name; but the carbunculus of Pliny was the ſame as the oriental ruby of our jewellers. Its colour is of a deep red inclining to purple. *See* RUBY.

CARDAMOM.

CARDAMOM. Neumann examined the leſſer cardamom. One ounce yielded a ſcruple of eſſential oil, containing the whole of their pungency and ſmell, with fourteen or fifteen grains of reſinous, and forty-five grains of mucilaginous extract.

CARDUUS BENEDICTUS. Four ounces of the leaves afforded four drams and a half of extract to ardent ſpirit: the ſame quantity gave out ſix drams and a half of mucilaginous extract with water. The expreſſed juice, depurated and evaporated to the conſiſtence of a ſyrup, afforded Neumann ſaline cryſtals, approaching to the nature of tartar.

CARLINE THISTLE. A prickly thiſtle, growing chiefly in Switzerland. Neumann ſpeaks of the roots, as brought in bundles from Thuringia. They have a bitter pungent taſte, and are chiefly uſed in the diſorders of cattle. In his method of treatment, he obtained by diſtillation about one ninth part of its weight of eſſential oil. Ardent ſpirit extracted more than one fourth of reſinous matter, which poſſeſſed the flavour and activity of the root. Water extracted a weaker matter.

CARMINE. A red pigment prepared by diſſolving cochineal in an alkaline lixivium, and precipitating by alum. It conſiſts, therefore, of the colouring matter of cochineal combined with the argillaceous earth of the alum.

Other precipitates are alſo called by this name. Lewis aſſerts, that he has often repeated with ſucceſs an experiment, firſt publiſhed in the Acta Naturæ Curioſorum, in which a fine precipitate, little inferior in beauty to carmine, is afforded by adding the nitrous ſolution of tin to a decoction of Brazil wood.

CARNELIAN. A ſtone of the ſiliceous genus, of different ſhades of brownish red or fleſh colour. The ſeveral ſpecimens vary alſo in their hardneſs and tranſparency. The moſt eſteemed is of an orange or yellowiſh red, and gives fire with ſteel. The whitiſh are ſofter and leſs valued. Ignition changes the red colour to an opake white. Its ſpecific gravity is from 2, 6 to 2, 7.

CARPOLITHI. A name given by writers on foſſils to ſuch ſtones as repreſent fruit. The baſis is a martial jaſper, in which nodules of rounded calcareous ſpar and ſerpentine are included. Denominations of this kind are at preſent little regarded.

CARTHAMUS, or SAFFLOWER. In ſome of the deep reddiſh, yellow, or orange coloured flowers, the yellow matter ſeems to be of the ſame kind with that of the pure yellow flowers; but the red to be of a different kind from the pure red ones. Watery menſtrua take up only the yellow, and leave the red, which may afterwards be extracted by rectified ſpirit of wine, or by a weak ſolution of alkali. Such particularly are the ſaffron-coloured flowers of carthamus. Theſe, after the yellow matter has been extracted by water, are ſaid to give a tincture to ley; from which, on ſtanding at reſt for ſome time, a deep red fecula ſubſides, called ſafflower, and from the countries whence it is commonly brought to us, Spaniſh-red and China-lake. This pigment impregnates ardent ſpirit with a beautiful red tincture; but communicates no colour to water. *Lewis* on *Neumann*.

CASE-HARDENING. Steel when hardened is brittle, and iron alone is not capable of receiving the hardneſs ſteel may be brought to poſſeſs. There is nevertheleſs a variety of articles in which it is deſirable to poſſeſs all the hardneſs of ſteel, together with the firmneſs of iron. Theſe requiſites are united in the art of caſe-hardening, which does not differ from the making of ſteel, except

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in the ſhorter duration of the proceſs. Tools, utenſils, or ornaments intended to be poliſhed, are firſt manufactured in iron and nearly finiſhed, after which they are put into an iron box, together with vegetable or animal coals in powder, and cemented for a certain time. This treatment converts the external part into a coating of ſteel, which is uſually very thin, becauſe the time allowed for the cementation is much ſhorter than when the whole is intended to be made into ſteel. Immerſion of the heated pieces into water hardens the ſurface, which is afterwards poliſhed by the uſual methods.

CARYOPHYLLOIDES. A name given to a ſpecimen of mica, the ſcales of which are concentric and perpendicular. Cronſtedt.

CASIA FISTULARIS. The fruit of a tree growing in Egypt and in the Eaſt Indies. It is a large cylindrical pod or cane, containing, under an hard rind, a ſoft pulp lodged in a number of tranſverſe cells, with a flat roundiſh ſeed in each. Out of four drams of the dried pulp, Neumann found water take up three drams fifteen grains. Rectified ſpirit took up as much, or nearly ſo; but the ſpirit acted more ſlowly.

CASIA LIGNEA. The bark of a tree of the ſame kind as the cinnamon tree. It contains an eſſential oil of the ſame flavour and qualities as that of cinnamon; but much leſs in quantity. Caſia is very commonly ſold under the name of cinnamon, from which however its external appearance is ſufficient to diſtinguiſh it. The caſia is thick, rough, and breaks croſs-wiſe without ſpliting; but the cinnamon is ſmoother, thinner, and cannot eaſily be broken croſs-wiſe without cauſing it to ſplit into many thin fragments.

CASTOR. A ſoft greyiſh yellow or light brown ſubſtance found in four bags in the inguinal region of the beaver. In a warm air it grows by degrees hard and brittle, and of a darker colour, eſpecially when dried in chimneys, as is uſually done. No experiments have been made ſufficient to ſhew its component parts with preciſion. Ardent ſpirit extracts a reſinous matter which colours it; water takes up an abundant mucilaginous principle, and affords by evaporation a ſaline ſubſtance not yet examined.

Caſtor is regarded as a powerful antiſpaſmodic.

CAT'S EYE. Pſeudopalus. A ſemi-opake ſtone of the ſiliceous order, and reckoned among the gems. It is whitiſh, and reflects green and yellowiſh rays, varying according to the poſition of the obſerver. It is very hard, and is uſually cut by jewellers of the figure of a plano-convex lens, and ſet with the convex ſide outwards. The beſt of theſe ſtones are very ſcarce. Bomare informs us that there was one in the cabinet of the Grand Duke of Tuſcany, of one inch diameter.

CAUSTIC (COMMON). A fixed alkali deprived of aerial acid and moſt of its water. If the lixivium of the ſoap-boilers be evaporated to dryneſs in a ſilver or copper veſſel, then fuſed in a crucible, poured out into a baſon, and, when ſolid, cut into ſmall pieces, it forms the common cauſtic. This muſt be kept in a cloſed bottle to prevent its deliqueſcing.

When a piece of this alkali is applied to the ſkin, for the ſpace of three quarters of an hour, it corrodes it, no doubt by forming a ſaponaceous compound with its fat parts. It was much uſed in making iſſues, before that practice was laid aſide. *See* ALKALI.

CAUSTIC, LUNAR. This is likewiſe, though improperly, called lapis infernalis. It conſiſts of the cryſtals of ſilver obtained by ſolution in nitrous acid, and afterwards fuſed in a crucible. To make this preparation, very pure

ſilver muſt be diſſolved to ſaturation in nitrous acid, and the cryſtals ſeparated by evaporation and cooling. Theſe are to be fuſed in an earthen crucible, ſufficiently large to admit of the frothing and ſwelling that happen at the commencement of the fuſion. The heat muſt be gentle, becauſe the cryſtals are very fuſible, and the acid eaſily decompoſed and driven off. It requires however to be ſomewhat raiſed after the ebullition has ceaſed. As ſoon as the matter is in quiet fuſion, it is to be poured into a mould, conſiſting of five or ſix ſmall cylindrical cavities, by which it acquires the form of ſmall pencils, and may conveniently be held in a caſe inſtead of touching it with the fingers.

Lunar cauſtic is black, which ſeems to ariſe from part of the acid being driven off, and a portion of the ſilver revived. Its cauſticity or action on animal ſubſtances appears to depend on the ſtrong diſpoſition of the ſilver to recover its metallic ſtate, and conſequently is a true combuſtion.

CAUSTICITY. All ſubſtances which have ſo ſtrong a tendency to combine with the principles of organized ſubſtances, as to deſtroy their texture, are ſaid to be cauſtic. The chief of theſe are the concentrated acids, pure alkalis, and the metallic ſalts.

CAWK. A term by which the miners diſtinguiſh the opake ſpecimens of vitriolated ponderous earth, or marmor metallicum. *See* EARTH PONDEROUS.

CEMENT COPPER. Copper precipitated from vitriolic waters by iron. The name is ſaid to be derived from a vitriolic water in Hungary called Ziment.

CEMENTATION. A chemical proceſs which conſiſts in ſurrounding a body in the ſolid ſtate with the powder of ſome other bodies, and expoſing the whole, for a time, in a cloſed veſſel, to a degree of heat not ſufficient to fuſe the contents. Thus iron is converted into ſteel by cementation with charcoal: green bottle glaſs is converted into porcelain by cementation with ſand, &c. *See* IRON, PORCELAIN.

The effects of cementation appear to be chiefly produced by one or more of the bodies being converted into vapour, and acting upon the others. The change in the ſolid is chiefly attended to. The powder is called by the name of a cement.

CENTAURY. The leaves of the leſſer centaury contain a bitter ſubſtance, ſoluble in water and in ardent ſpirit. The green colour of the plant reſides in the reſinous part, being extracted by ardent ſpirit, but not by water.

CERUSE, or WHITE LEAD. A calx of lead produced by expoſing this metal to the vapours of vinegar. To prepare this colour, the lead is caſt into plates about one twentieth part of an inch thick, four or five inches wide, and two feet long. Theſe are rolled up in a ſpiral form, in ſuch a manner that the ſpace of half an inch is left between each revolution. They are then placed in earthen pots which have three projections within, to prevent them from reſting on the bottom. Some good vinegar is then poured in, ſo as to reach no higher than the lower edge of the leaden ſpiral, and the pots are then buried in dung beneath ſheds. A great number of theſe are diſpoſed beſide each other, each pot being covered with a leaden plate and boards, by which contrivance the number of pots is multiplied by placing them above each other in ſtrata. At the expiration of a month or ſix weeks they are taken out, and the white lead ſeparated by unrolling the coils. It is then ground in mills, and dried in the ſhade for uſe.

Some writers diſtinguiſh this calx by the name of white lead, and apply the term ceruſe to denote a mixture of white lead and chalk.

Lead is found native in the form of ceruſe, or the white calx.

CERUSE OF ANTIMONY. A white calx of this ſemi-metal, which ſeparates from the water in which diaphoretic antimony has been waſhed.

CHALCEDONY, or WHITE AGATE. A flint of a white colour, reſembling milk diluted with water, and more or leſs opake, with veins, circles, or ſpots. It is ſaid to be ſofter than the onyx, but much harder than the agates of the ſame colour as the onyx. Bergman obſerves that it varies greatly in ſpecific gravity; from 2,5 to 4,6. He found the chalcedony of Ferro to contain 84 parts ſilex, and 16 clay.

CHALK. A very common ſpecies of calcareous earth, of an opake white colour, very ſoft, and without the leaſt appearance of a poliſh in its fracture. Its ſpecific gravity is from 2,4 to 2,6, according to Kirwan, who likewiſe informs us that this ſubſtance contains more fixed air than any other variety of the calcareous claſs; generally about forty per cent. It contains a little ſiliceous earth, and about two per cent of clay. Some ſpecimens, and perhaps moſt, contain a little iron, and Bergman affirms that marine ſalt of lime, or magneſia, is often found in it; for which reaſon he directs the powder of chalk to be ſeveral times boiled in diſtilled water, before it is diſſolved for the purpoſe of obtaining pure calcareous earth. Sciag. Regni Min. § 92.

CHALK, RED. This is a clay coloured by the calx of iron, of which it contains from 16 to 18 parts in the hundred, according to Rinman.

CHALK, SPANISH. The ſoap rock, or lapis ollaris, is frequently diſtinguiſhed by this name.

CHARACTERS CHEMICAL. Language in its uſual conſtruction is very far from being capable of expreſſing our conceptions with the rapidity and perſpicuity neceſſary for the adequate communication of ideas. Writing is ſtill ſlower and leſs perfect. But as the language and the writing we poſſeſs are capable of ſupplying our groſſer and more immediate wants, it is much to be feared that neither the one nor the other will ever be carried to thoſe degrees of perfection of which they are certainly ſuſceptible. A few attempts have nevertheleſs been made from time to time; but they have in general been fruſtrated by the indolence of the multitude, who are at all times more diſpoſed to uſe a bad inſtrument than take the trouble to learn the uſe of a good one. The chemical characters are, in ſome meaſure, an inſtance of this. They were invented by the earlier chemiſts, probably with no other view than to ſave time in writing the names of ſubſtances that frequently occurred, in the ſame manner as we avoid repetitions by the uſe of pronouns. But the moderns ſeem to have conſidered them as relics of alchemiſtical obſcurity, and have almoſt rejected their uſe, without enquiring whether they may not poſſeſs advantages far ſuperior to thoſe of the common literal enunciation.

We need not have recourſe to the remote field of Chineſe literature, to ſhew how admirably the ſimplicity, relative poſition and connection of characters are calculated to expreſs ideas, at one glance of the eye, with a degree of accuracy and preciſion not to be obtained by the uſe of many written words. Neither need we recur to the ſcience of algebra, where by the uſe of characters the mind receives the proof, and aſſents to propoſitions almoſt inſtantaneouſly, which would have required a long ſeries of verbal deductions in any other way. Our own ſcience, chemiſtry, will afford us inſtances of the moſt ſtriking nature. The tables at the end of Bergman's Eſſay on the Affinities exhibit, in the moſt

ſpeedy and intelligible manner, the greater part of many volumes of chemical reſults; and I know, from my own experience, that it is eaſy, by a ſimple combination of chemical and algebraical characters, to write the whole contents of any chemical work in the ſmall margin uſually left by the printer; and that in a manner ſo full, clear, and perſpicuous, that whole pages may be read and underſtood in a few ſeconds. This will be readily allowed by any chemiſt who will make the trial, and will be done with eaſe by thoſe who are acquainted with the characters and methods of the two ſciences; for which reaſon I hope to be acquitted of the contemptible ſpirit of reſerve, when I ſay that the limits of the preſent work, and a wiſh to purſue the ſubject a little farther, prevent me from entering into it at preſent.

Characters are either entirely arbitrary, or they have ſome reſemblance to the idea they repreſent. The latter property is naturally aimed at, where it can be obtained, becauſe it cannot but tend to aſſiſt the memory. Thus a number of dots were uſed to denote ſand or powder; the figure of a retort, to denote the retort, &c. and the combination of characters is uſed to denote ſimilar combinations of the ſubſtances they repreſent. Very little of ſyſtem appears in the ancient characters of chemiſts: the characters of Bergman are chiefly grounded on the ancient characters, with additions and improvements. But the characters of Haſſenfratz and Adet are ſyſtematical throughout. The two former are exhibited in Plate III, and the latter in Plate IV.

CHARCOAL. When vegetable ſubſtances are expoſed to a ſtrong heat in the apparatus for diſtillation, the volatile principles fly off, but combuſtion does not take place for want of air. The fixed reſidue is the inflammable ſubſtance called charcoal. For general purpoſes, wood is converted into charcoal by building it up in a pyramidal form, covering the pile with clay or earth, and leaving a few air-holes, which are cloſed as ſoon as the maſs is well lighted; and by that means the combuſtion is carried on in an imperfect manner. Common charcoal, when expoſed to heat in the diſtilling apparatus, gives out a ſmall quantity of inflammable air, which ſeems extraneous to it, or may ariſe from decompoſed water. But if it be burned by admitting vital air into an inverted veſſel, the volatile product is found to be fixed air, and nothing but a very ſmall reſidue of ſaline and earthy matter remains behind. That the product is merely fixed air, is proved by abſorbing it by fixed alkali. The whole either diſappears, or the reſidue conſiſts of vital air as pure as at firſt*.

From this and ſimilar facts, the antiphlogiſtian chemiſts conſider the acidification of charcoal, or its converſion into fixed air, or the aerial acid, as a proceſs exactly of the ſame nature as the acidification of ſulphur, or of phlogiſticated air, by which the vitriolic and nitrous acids are produced. And as they conſider thoſe baſes to be ſimple ſubſtances, relative to the ſtate of our knowledge, which become acidified merely by combining with vital air, ſo likewiſe they account pure charcoal to be the ſimple acidifiable baſis of the aerial acid, firſt called fixed air. The phlogiſtians ſuppoſe charcoal to afford inflammable air, which according to them forms fixed air when it meets with vital air, itſelf being in the naſcent ſtate.

Charcoal is black, ſonorous, and brittle, and in general retains the figure of the vegetable it was obtained from. If, however, the vegetable conſiſts for the moſt

* Lavoiſier in Mem. Acad. Par. 1781, p. 449.

part

part of water or other fluids, theſe in their extrication will deſtroy the connection of the more fixed parts. In this caſe the quantity of charcoal is much leſs than in the former. The charcoal of oily or bituminous ſubſtances is of a light pulverulent form, and riſes in ſoot. This charcoal of oils is called lamp-black.

It is a remarkable fact, that well-burned charcoal is a conductor of electricity; though the electric matter is not at all conveyed through wood which is ſimply baked or deprived of moiſture.

Charcoal reſiſts the ſtrongeſt heat in well cloſed veſſels. If it be ignited, it abſorbs elaſtic fluids with great avidity as it cools; and it retains the property if cooled by immerſion in mercury, the abſorption being equally conſiderable when it is afterwards expoſed to the air.

The diſpoſition to be burned, which in the ancient theory is ſuppoſed to conſiſt in the giving out of phlogiſton, and, in the modern theory, in the abſorption of vital air, is ſo great in charcoal that it performs the reverſe of combuſtion in a great variety of inſtances. Thus it converts the vitriolic acid into vitriolic air by increaſing the proportion of ſulphur, and it is ſtrongly acted on by the nitrous acid, much nitrous air being extricated at the ſame time. The rapidity with which nitrous acid acts on dry charcoal has already been mentioned (page 41). In either of theſe proceſſes, the acid either combines ſuddenly with the phlogiſton of the charcoal, or the vital air of the acid combines with the charcoal itſelf, conſidered as a ſimple ſubſtance.

The moſt violent combuſtion or detonation of charcoal with nitre, in which the acid is entirely decompoſed, may be explained in either way by the two theories. *See* GUNPOWDER.

Alkalis diſſolve charcoal in the dry way, and liver of ſulphur unites very readily with it, either in the dry or moiſt way. All the metallic ſubſtances hitherto known are more combuſtible than charcoal, and conſequently are revived or reduced to the metallic ſtate, by being heated with this ſubſtance. This, in the ancient theory, denotes that all the metals attract phlogiſton more ſtrongly than charcoal does; but in the new theory the effect is aſcribed to the ſtronger attraction of charcoal, which deprives all metallic calces of the vital air which combined with them during their calcination.

An important conſequence ſeems to follow from this circumſtance, namely, that there may exiſt many metallic ſubſtances whoſe combuſtibility may be greater than that of charcoal, and which conſequently are unknown to us as ſuch, becauſe we poſſeſs no means of reducing them. Thus the alkalis and earths may conſiſt of peculiar combuſtible or metallic ſubſtances, dephlogiſticated or combined with vital air, by an union which the art of chemiſtry has not yet found means to break.

The reſidue of charcoal burned in the open air conſiſts of a ſmall quantity of aſhes, which contain alkaline and neutral ſalts. The vegetable alkali is found in the aſhes of various plants, and is known under the names of pot-aſh, pearl-aſh, cendres gravelées, &c. It is not eaſy to purify it by a cheap proceſs from the neutral ſalts it may be contaminated with. Mineral alkali is found in the aſhes of none but marine plants. The neutral ſalts found in the aſhes of vegetables are vitriolated tartar, Glauber's ſalt, ſelenite, common ſalt, and ſalt of Sylvius. Calces of iron and manganeſe, with an earthy ſubſtance, compoſe the inſoluble reſidue. What this earthy ſubſtance may be, has not been determined; but it moſt probably conſiſts of ſome inſoluble earthy ſalt, ſuch as phoſphorated lime.

CHATOYANT.

CHATOYANT. A term applied, by the French, to denote that affection of ſemi-tranſparent ſtones by which their colours vary according to the poſition of the eye of the obſerver. We have not a correſpondent Engliſh word; for which good reaſon this word has been adopted by ſeveral writers on mineralogy.

CHEESE. It is a well known fact, that milk conſiſts of butter, cheeſe, a ſaccharine matter called ſugar of milk, and a ſmall quantity of common ſalt, together with much water. Our chemical knowledge of this fluid, before the time of Scheele, conſiſted of little more than the common operations of the dairy, and the reſults of the inaccurate method of decompoſition by fire. This celebrated chemiſt, in his Eſſay on Milk and its Acid, relates a variety of intereſting experiments, from which we ſhall at preſent extract ſo much as relates to the caſeous part.

If any vegetable or mineral acid be mixed with milk, the cheeſe ſeparates, and, if aſſiſted by heat, coagulates into a maſs. The quantity of cheeſe is leſs when a mineral acid is uſed. Neutral ſalts, and likewiſe all earthy and metallic ſalts, ſeparate the cheeſe from the whey. Sugar and gum arabic produce the ſame effect. Cauſtic alkalis will diſſolve the curds, by the aſſiſtance of a boiling heat, and acids occaſion a precipitation again. It does not appear, however, that the cheeſy part is diſſolved in milk by means of an alkali, as was aſcertained by adding an acid to milk, which ought to have produced a neutral ſalt, if this had been the caſe, but did not. The true reaſon why acids cauſe the cheeſy matter to ſeparate is, that they combine with it, and form a compound much leſs ſoluble in water than the cheeſe itſelf. Eight parts of water diſſolved one part of the curd precipitated by a mineral acid; ſo much of the acid having been previouſly mixed with the water as to give it a ſour taſte. Vegetable acids have very little ſolvent power upon curds. This accounts for a greater quantity of curd being obtained when a vegetable acid is uſed.

Scheele thinks that neutral ſalts, gums, and ſugar produce a coagulation of curds by virtue of their ſtronger attraction for the water.

He conſiders cheeſe as an animal gelatinous ſubſtance, or rather ſerous matter. For we would wiſh to confine the word gelly to ſuch adheſive animal ſubſtances as become more fluid by heat, whereas ſerum coagulates at a certain temperature. He found that curds, after repeated abſtractions of nitrous acid, left a white reſidue conſiſting of nitrated lime and an animal earth. This animal earth, which may be ſuppoſed to be phoſphorated lime, amounted to one tenth of the whole weight.

The white of egg, according to this chemiſt, is nothing elſe but pure cheeſe. When this ſubſtance is coagulated by means of heat, it may be diſſolved by boiling in very dilute mineral acids, which ſolution is again precipitated by adding ſome concentrated acid; a phenomenon that likewiſe happens with the acid ſolutions of curd or cheeſe.

CHEMISTRY. It is uſual with writers to define the ſcience of chemiſtry before they proceed to treat on it. It ſeldom happens, however, that deſcriptions of very complicated objects can poſſeſs that neatneſs and preciſion which are eſſential to a good definition. Chemiſtry was formerly conſidered as a mere art, at preſent it is juſtly regarded as one of the moſt ſublime and important of the ſciences. In its object it embraces the whole of natural phenomena, there being few changes, comparatively ſpeaking, which are not attended with ſome effect that comes under the conſideration of this ſcience. We might define it negatively,

negatively, by affirming that every effect which is not purely mechanical is chemical; and in purſuance of this view of the ſubject, we ſhould ſay that chemiſtry, as a ſcience, teaches the methods of eſtimating and accounting for the changes produced in bodies, by motions of their parts amongſt each other, which are too minute to affect the ſenſes individually; and as an art, we ſhould affirm that it conſiſts in the application of bodies to each other, in ſuch ſituations as are beſt calculated to produce thoſe changes.

CHERT or CHERTZ. Petroſilex ſemipellucidus, lapis corneus, hornſtein of the Germans. Chert is a ſemi-tranſparent ſtone of the ſiliceous kind. It is generally leſs hard, and of a coarſer texture than common flints. Large quantities of chert are found in beds of lime-ſtone, as flints are found in the beds of chalk; with this difference, that flint conſiſts of looſe nodules, and chert often forms large maſſes of the rock. They are uſed as grinding-ſtones for grinding calcined flints and other hard ſubſtances, but have too ſmooth and cloſe a texture for the grinding of corn.

CHRYSOCOLLA. The Greek name for BORAX, which ſee. The ancients likewiſe uſed it to denote Mountain Green, Viride Montanum.

CHRYSOLITE. The oriental chryſolite and peridot are the ſame gem. It becomes electric by being rubbed: its form is priſmatic, of ſix and ſometimes of five ſtriated faces. They are found in the Eaſt Indies, Brazil, Bohemia, Saxony, and Spain; in Bourbon and Auvergne in France; and in Derbyſhire in England. Some are likewiſe found with volcanic lavas, as in the Vivarais, where ſome large lumps have been ſeen of twenty and thirty pounds weight. But it is remarkable, that ſome of theſe chryſolites are partly decompoſed into an argillaceous ſubſtance.

However, all chryſolites are far from being of the ſame kind: the oriental ones only differ on account of their green hue, from thoſe ſapphires, topazes, and rubies of the ſame denomination. Theſe do not loſe their colour or their tranſparency in the fire: but the chryſolite either becomes opake by a ſtrong heat, or is entirely fuſible; and it phoſphoriſes in the inſtant it melts, like the baſis of alum and gypſeous ſpar: with borax it produces a thin colourleſs glaſs.

Its ſpecific gravity is between 3,600 and 3,700: according to Briſſon, and that of the Spaniſh chryſolite 3,0989.

Its ſubſtance is lamellated in the direction of the axis of its primitive form; but the chryſolite from Saxony is foliated in a perpendicular poſition to the ſame axis.

The chryſolite of the ancients was the ſame gem which is now called topaz, and the name of itſelf indicates that it ought to be ſo. Pliny very plainly ſays, (b. 37. c. 9.) that the colour of the chryſolite is yellow like gold.

CHRYSOPRASE. Mr. Achard has made the analyſis of chryſopraſe from Koſeinitz in Sileſia, which loſt its colour and tranſparency in the fire, becoming cracked and white in its ſurface, but without melting. Its powder, either with ſalt of tartar, mineral alkali, nitre, or borax, gave a diaphanous glaſs; and with other ſubſtances produced opake maſſes of different colours.

The chryſopraſe is of a green colour, deeper than the chryſolite, but with a yellowiſh tinge, inclining to blue, like the green leek, as Pliny ſays (b. 37. c. 8). Mr. Achard ſays, that it never is found cryſtalliſed, and that it is ſemi-tranſparent. Mr. Romé de Liſle reckons it amongſt the quartz, and ſays that its colour is owing to the mixture of cobalt, as it gives a fine blue glaſs when fuſed

with

with borax, or with fixed alkali. But Mr. Achard found the glaſs of a deep yellow, when the fuſion was made with borax; and that it really contains ſome calx of copper inſtead of cobalt. Mr. Dutens ſays, that ſome gold has been found in this kind of ſtone: but this laſt, in all probability, belongs to ſome other claſs of ſubſtances, viz. to the vitreous ſpars.

CINNABAR. An ore of mercury, conſiſting of that metal united with ſulphur. This combination is alſo made by art. The native cinnabar is of different ſhades, from yellowiſh to a deep red, and even black. It is found either in hard or friable maſſes, irregularly figured or cryſtallized in cubes ſometimes, though rarely tranſparent, and its texture is either radiated, ſtriated, ſcaly, or granular. One hundred parts contain pretty regularly eighty parts mercury and twenty ſulphur. In cloſed veſſels it ſublimes by heat, but in open veſſels it is decompoſed.

The principal cinnabar mines which are wrought in Europe are thoſe of the Palatinate and thoſe of Spain. In the Palatinate the ore is decompoſed by mixing it with one third of its weight of lime, and diſtillation in iron cucurbits one inch thick, three feet nine inches long, one foot wide, with an aperture of five inches. Theſe veſſels are diſpoſed in a gallery; forty-eight being arranged in two parallel lines, a ſecond row above the firſt. An earthen pot is one third part filled with water, adapted to the neck of each cucurbit, and accurately luted on. The gallery is heated by a fire lighted at the two ends, and ſeveral apertures, formed in the upper part, ſerve the purpoſe of chimneys. The heat is kept up for ten or twelve hours before the proceſs is finiſhed.

The above proceſs was alſo followed at Almaden in Spain, till the year 1647, when the following was adopted on account of its greater ſimplicity and economy. The furnace is twelve feet high, and four feet and a half diameter within. At the diſtance of five feet and a half from the ground is an arched floor, upon which the ore is depoſited, and a fire is kindled in the aſh-hole. The ſublimed mercury eſcapes through twelve apertures, formed in the upper part of the laboratory. To theſe apertures rows of aludels inſerted one in the other are adjuſted, and diſpoſed parallel upon a terrace, which terminates in a ſmall building ſeparated into as many chambers as there are files of aludels. Each chamber has a cavity in the middle, to receive the ſmall quantity of mercury which may arrive to that diſtance.

Every furnace contains two hundred quintals of cinnabar, and the fire is kept up for three days. The ſulphur which burns is diſengaged in the form of ſulphureous acid, and eſcapes through ſmall chimneys made in each chamber. Every repetition of the proceſs affords from twenty-five to ſixty quintals of mercury.

The mine of Almaden has been wrought from time immemorial. Its veins are from three to fourteen feet in breadth; and their breadth is even larger where they join.

Artificial cinnabar is known in commerce by the name of vermilion, and ought to be uſed in all caſes wherein this compound is meant to be applied to medical purpoſes, on account of its greater purity. The manufacture of this pigment has long been in the hands of the Hollanders, who kept it a ſecret; and as there is ſome difficulty in perfectly ſucceeding in the proceſs, chemical writers have given various methods of performing it; moſt of which, according to Mr. Tuckert, are innacurate. This gentleman has given a full account of the method

method uſed at Amſterdam, which I find extracted from Crell's Chemical Journal, and inſerted in the fourth volume of the Annales de Chimie. Its contents are as follow:

The manufactory, at which Mr. Tuckert ſeveral times aſſiſted, in the preparation of artificial cinnabar, is without the Utrecht port at Amſterdam, and is one of the moſt conſiderable in Holland. Forty-eight thouſand pounds of vermilion are annually made in three furnaces by four workmen, beſides other mercurial preparations.

The ethiops mineral is firſt prepared by mixing together 150 pounds of ſulphur with 1080 pounds of pure mercury, and then expoſing the mixture to a moderate heat in a flat-bottomed poliſhed iron veſſel, one foot in depth, and two feet and a half in diameter: its form is that of a chocolate machine. Mr. Tuckert does not enter into the particular manipulations of the Hollanders in this part of the proceſs, becauſe the methods of producing the black combination of mercury with ſulphur are well known.

The mercurial ethiops thus prepared is in the next place pounded, in order that it may more readily be put into ſmall earthen bottles, capable of holding each about 24 ounces of water. Thirty or forty of theſe bottles are filled to be in readineſs for the ſubſequent operation.

In the next place three large pots, or ſublimatory veſſels, made of clay and very pure ſand, are taken. Theſe veſſels are previouſly covered with a coating of lute, which is ſuffered to become perfectly ſolid and dry before the veſſel is uſed. Mr. Tuckert refers to a German tranſlation of a work of Mr. Machy for the figure of theſe veſſels, as well as for the compoſition of the lute. As we have not that tranſlation, it is impoſſible for us to give any further information on theſe heads than may be gathered from the reſt of his memoir. Theſe pots are placed over three furnaces, upon iron circles. The ſublimatory veſſels may be of different ſizes, and the furnaces are conſtructed in ſuch a manner as that the flame circulates freely round the veſſels to two thirds of their height.

When the veſſels are duly placed in their furnaces, a moderate fire is firſt lighted, which is gradually raiſed until they become red hot. The fuel is turf, or rather peat, commonly uſed throughout the United Provinces. As ſoon as the veſſels are red hot, a bottle of the ethiops is poured into the firſt, another into the ſecond, and another into the third. In the ſubſequent progreſs of the operation, two, three, and perhaps more bottles may be poured in at a time; but this depends on the ſtrength of the inflammation exhibited by the ethiops after its introduction, the flame of which ſometimes riſes to the height of four, and even ſix feet. When this is a little diminiſhed, the mouth of the veſſel is covered with a plate of iron, one foot ſquare, and an inch and a half thick, which perfectly cloſes it. In this way, during thirty-four hours, the whole of the prepared matter is introduced into the three pots; that is to ſay, for each pot three hundred and ſixty pounds of mercury, and fifty of ſulphur.

After all the ethiops has been introduced, the fire is duly kept up; and when the whole ſublimation has taken place, it is ſuffered to go out, which requires thirty-ſix hours from firſt to laſt. The workmen know when the fire is too ſtrong or too weak by the appearance of the flame when the iron cover is taken off: if too ſtrong, the flame riſes to the height of ſeveral feet; if, on the contrary, it be too weak, the flame barely appears playing about the edges of the pot. The proper degree of heat is when, upon taking off the cover, a briſk

flame appears, but does not riſe more than three or four inches above the opening.

In the laſt thirty-ſix hours, the maſs was ſtirred every quarter or half hour with an iron triangle, to accelerate the ſublimation. The workmen do this with ſo much courage, that Mr. Tuckert was every time apprehenſive they would fall into the veſſels.

When the whole is cool, the veſſels are taken out by means of iron circles, which prevent their breaking. The cinnabar is taken out by breaking the veſſel. Each veſſel conſtantly affords four hundred pounds of cinnabar, the loſs of original weight in each being ten pounds.

The cinnabar does not attach itſelf to the plates of iron, becauſe they are ſo frequently taken off, excepting towards the end, when the veſſels were left untouched. Theſe plates are not in the leaſt corroded.

The workmen were Germans, and were paid as follows. The foreman, beſides his lodging, received twelve guilders a week, which amount to twenty-two ſhillings and nine-pence of our money; the ſecond received ten guilders, or eighteen ſhillings and three pence; the third and the fourth received ſix or ſeven guilders. They relieve each other night and day, every twelve hours, except holidays and Sundays, ſo that two men are always at work.

The workmen aſſured Mr. Tuckert, that they did not remember any accident having happened in the manufactory, though the foreman had been employed for thirteen years; and that, in caſe of an accident, the whole loſs would conſiſt in the broken pot.

Theſe four workmen likewiſe manufactured on the ſame premiſes the corroſive ſublimate of mercury, and the red calx called red precipitate. The foreman delivers monthly to Mr. Brand the cinnabar and other products of the manufactory, and receives in exchange ſulphur, mercury, martial vitriol, common ſalt, and nitre.

CINNAMON is the bark of a tree of the bay kind, growing in the iſland Ceylon, called by Hermann laurus zeylanicus baccis calliculatis. Though the bark is one of the moſt grateful ſpices, the wood is inſipid and inodorous, and uſed only as firewood: the root is impregnated with aromatic matter, and yields in diſtillation not only an eſſential oil, but a portion of camphor. The bark is taken off twice a year; in the ſpring, before the tree begins to bloſſom, and in autumn, after the fruit has fallen. It is taken only from young trees, that of the old being woody and bitteriſh.

It has been obſerved that the thin membrane, which inveſts the internal ſurface of the bark, is vaſtly ſtronger in ſmell and taſte than the bark itſelf. Some ſuppoſe that the aromatic matter is originally confined wholly to this membrane, and thence communicated to the exterior parts in drying. Lemery is of opinion that cinnamon receives all its ſmell and taſte from the action of the ſun in its exſiccation. This can be no otherwiſe true, than as the active parts are more concentrated by the diſſipation of the watery. Hermann aſſures us, that it is not in the ſun, but in the ſhade, that the bark is dried.

Cinnamon has a very agreeable pungent, ſomewhat aſtringent taſte, and a delightful ſmell. Its eſſential oil is extremely pungent and fiery, but in ſmall quantity, ſixteen ounces of the very beſt cinnamon ſcarcely yielding two ſcruples and a half. The diſtilled water appears milky, and retains in it greateſt part of the oil, which, on long ſtanding, it depoſites to the bottom, and then becomes

clear. Oftentimes, though ſeveral pounds of cinnamon be committed to diſtillation, we ſhall ſcarcely be able to ſeparate any oil till the water has been kept for ſome months. Mr. Stoll of Leipſick pretends to have a method of collecting all the oil from the water in a very little time; how juſtly, I cannot determine. If this ſhould be found practicable, it would be a very uſeful diſcovery, provided the oil received no injury. The Dutch, who are maſters of the ſpice iſlands, are the only perſons who prepare the oil of cinnamon in quantity; but it never comes from their hands unadulterated. We ſeldom meet with oil of cinnamon that holds leſs than half its weight either of expreſſed oil or of ſpirit of wine.

The oil of this ſpice does not ariſe in diſtillation with rectified ſpirit: on diſtilling pure ſpirit from cinnamon, it received no ſenſible impregnation; on drawing it over repeatedly from freſh parcels of the ſpice, it ſmelt and taſted a little, but very weakly. An extract made by ſpirit contains the whole of the taſte and flavour of the cinnamon. The watery extract has nothing valuable; ſixteen ounces yield two or more of ſpirituous extract, and about one and a half of watery.

CIPOLIN. The cipolin from Rome is a green marble with white zones: it gives fire with ſteel, though difficultly. One hundred parts of it contain 67,8 of mild calcareous earth, 25 of quartz, 8 of ſhiſtus, 0,2 of iron, beſides the iron contained in the ſhiſtus. The cipolin from Autun contains 83 parts mild calcareous earth, 12 of green mica, and one of iron.

CIRCUMCISION-STONE. A variety of the jade or jaſpachates which comes from the Amazon river. It melts by the ſolar heat into a brown opake glaſs, leſs hard than the ſtone itſelf.

CIVET is collected betwixt the anus and the organs of generation of a fierce carnivorous quadruped met with in China and the Eaſt and Weſt Indies, called a civet-cat, but bearing a greater reſemblance to a fox or marten than a cat.

Several of theſe animals have been brought into Holland, and afford a conſiderable branch of commerce, particularly at Amſterdam. The civet is ſqueezed out, in ſummer every other day, in winter twice a week; the quantity procured at once is from two ſcruples to a dram or more. The juice thus collected is much purer and finer than that which the animal ſheds againſt ſhrubs or ſtones in its native climates.

Good civet is of a clear yellowiſh or browniſh colour, not fluid, nor hard, but about the conſiſtence of butter or honey, and uniform throughout; of a very ſtrong ſmell, quite offenſive when undiluted, but agreeable when only a ſmall portion of civet is mixed with a large one of other ſubſtances.

This commodity is rarely or never to be met with genuine, notwithſtanding the ſealed bottles in which it is purchaſed at Amſterdam. Nor have we any certain criteria for diſtinguiſhing its adulteration. Some look upon it as genuine, if when rubbed upon paper it ſinks in, without leaving any thing upon the ſurface; and if, when melted in hot water, it totally ſwims at top: but lard and butter, the ſubſtances principally mixed with it, have both theſe properties equally with the civet itſelf.

Civet unites eaſily with oils, both expreſſed and diſtilled, but not at all with ſpirits of wine, nor with water: nor is it rendered miſcible with water by the mediation of ſugar. Boecler relates, that ſugar and rectified ſpirit are its two

beſt menſtrua; but he has certainly never made the experiment with either. The yolk of an egg ſeems to diſpoſe it to unite with water; but in a very little while the civet ſeparates from the liquor, and falls to the bottom, though it does not prove of ſuch a reſinous tenacity as when treated with ſugar and ſpirit of wine.

It communicates, however, ſome ſhare of its ſmell both to watery and ſpirituous liquors; hence a ſmall portion of it is often added in odoriferous waters and ſpirits; as thoſe of lilies of the valley, roſes, rhodium wood, orange flowers, orange peel, yellow ſaunders, &c. The Italians make it an ingredient in perfumed oils, and thus obtain the whole of its ſcent; for oils diſſolve the whole ſubſtance of the civet. Neumann.

CLAY. *See* EARTH, ARGILLACEOUS.

CLOVES. The pungency of cloves reſides in their reſin, or rather in a combination of reſin with eſſential oil, for the ſpirituous extract is very pungent; but if the oil and the reſin contained in this extract be ſeparated from each other by diſtillation, the oil will be very mild; and any pungency which it does retain proceeds from ſome ſmall portion of adhering reſin, and the remaining reſin will be inſipid. No plant, nor part of any plant, contains ſo large a portion of eſſential oil as cloves do. From ſixteen ounces, Neumann obtained by diſtillation two ounces and two drams; and Hoffman obtained from the ſame quantity an ounce and a half. The oil is ſpecifically heavier than water.

CLYSSUS. A word formerly uſed to denote the vapours produced by the detonation of nitre with any inflammable ſubſtance. It was prepared by uſing a tubulated earthen retort capable of ſupporting the ſudden application of ſtrong heat, together with a very large receiver, pierced with a ſmall hole. As ſoon as the bottom of the retort had become red hot, a ſmall quantity, between 60 and 100 grains, of a mixture of nitre and charcoal was thrown into the tube, which was immediately afterwards cloſed. Detonation of courſe took place: the elaſtic product conſiſting of fixed air from the charcoal, and phlogiſticated air from the nitrous acid, eſcaped for the moſt part through the perforation: and a ſmall quantity of fluid was condenſed in the receiver, conſiſting either of the mere water of cryſtallization, or of the ſame water contaminated with volatile alkali, no doubt produced by an union of phlogiſticated and inflammable air.

Other clyſſi were alſo produced, which had their names from the inflammable ſubſtance made uſe of; ſuch as the clyſſus of antimony and the clyſſus of ſulphur, both which, if the materials be duly proportioned, are merely the vitriolic acid air, or ſulphureous acid. *See* ACID, VITRIOLIC; alſo AIR, VITRIOLIC.

COAL. Vegetable coals are commonly diſtinguiſhed by the name of charcoal, which ſee. The word coal is with us almoſt excluſively applied to denote mineral or pit coal. Of this there are many varieties. They appear to conſiſt of petroleum, conſolidated with an earth chiefly of the argillaceous kind. This uſeful ſubſtance has been diſtinguiſhed into many varieties, reſpecting which much information may be derived from the Mineralogy of Kirwan, or more fully from that of Cronſtedt. The legiſlature, however, diſtinguiſh only two kinds relative to the duties payable thereon; namely culm, and caking coal. The former does not conſolidate by a kind of fuſion into larger maſſes, when heated, as the latter does, and cannot therefore be applied to ſuch a variety of uſes.

Pit-coal is uſually found in ſtrata in the earth, almoſt always in mountains of ſhiſtus or grit. It appears to be a general opinion, that this ſubſtance owes its origin to the decompoſition of vegetable bodies. And indeed, when we attend to the inflammable ſubſtances found in the earth, or in the mineral kingdom, we may perceive that very few, and moſt probably none of them, can be truly ſaid to belong to it, but have been elaborated in the bodies of animals or vegetables. From the turf that is pared from the ſurface of the earth, and owes its inflammability to the roots of vegetables which are mixed with it, we may deſcend to the peat, or black earth, of the moors, in many ſpecimens of which vegetable remains are ſtill perceptible; though in moſt they appear to be deprived of every appearance of their organic texture, their oily and inflammable nature only remaining; and from thence the tranſition to pit-coal is eaſy. For if we reflect on the vaſt revolutions which the earth has certainly undergone through a long courſe of ages, by means of which its ſurface has been broken, diſplaced and inverted, from the actions of floods, earthquake, and the great convulſions of nature cauſed by volcanic eruptions, it will be no improbable inference that the thin, though extenſive ſtrata of pit-coal, as well as the exſudations of naphtha, petroleum, and their modifications, have all ariſen from the burying of extenſive woody tracts of the ſurface, ſuch as are common in all uncultivated countries. And this probability will be reduced to a certainty when we advert to the natural hiſtory of pit-coal which is met with in all the various ſtates of transformation. Whole trees are converted into pit-coal, in ſuch quantities together as to exhibit entire foreſts; in which the roots, trunks, branches, bark, and even ſpecies, are diſcernible.

Coal pits and ſlate quarries exhibit innumerable marks of impreſſions of leaves, and other indications of their vegetable origin; and the analyſis of this combuſtible ſubſtance tends ſtill further to confirm this truth. On the other hand, if we attend to ſuch inferences as chemical theory might point out from the facts around us, we ſhall ſee how ſmall the probability is, that the mineral kingdom ſhould, after a certain limited time, contain inflammable bodies, if they were not occaſionally thrown into it, in conſequence of the operations carried on within organized ſubſtances. For all inflammable ſubſtances, tending to decompoſe the vital air of the atmoſphere, would, in proceſs of time, revert to the claſs of uninflammable bodies, if the operation of organized bodies, particularly of the vegetable kind, did not tend to diſengage the vital air again, and render bodies combuſtible, which were not ſo when they became parts of thoſe ſubſtances.

COATING, *or* LORICATION. Glaſs being a brittle ſubſtance, and at the ſame time a bad conductor of heat, is always liable to be broken by the expanſion of its outer ſurface, where heat is ſo ſuddenly applied that the expanſion of the inner part does not immediately take place. To prevent this, and alſo to obviate the ſame inconvenience ariſing from variations in the intenſity of the fire, it is uſual to have recourſe either to a ſand-bath, or to coating the veſſel.

Retorts may be coated in the following manner: Take of ſand and clay equal parts; make them into a thin paſte with freſh blood prevented from coagulating by agitation till it be cold, and diluted with water; add to this paſte ſome hair and powdered glaſs; with a bruſh dipt in this maſs beſmear the retort; and when this firſt layer is dry, let the ſame operation be repeated twice or oftener, till the coat applied be about one third part of an inch thick.

Chaptal

Chaptal recommends a ſoft mixture of marly earth, firſt ſoked in water, and then kneaded with freſh horſe-dung, as a moſt excellent coating.

The valuable method uſed by Mr. Willis of Wapping to ſecure or repair his retorts uſed in the diſtillation of phoſphorus, deſerves to be mentioned here. The retorts are ſmeared with a ſolution of borax, to which ſome ſlaked lime has been added, and when dry, they are again ſmeared with a thin paſte of ſlaked lime and linſeed oil. This paſte being made ſomewhat thicker, is applied with ſucceſs, during the diſtillation, to mend ſuch retorts as crack by the fire.

COBALT is a ſemi-metal, of a whitiſh grey or ſteel colour, hard and brittle; of a dull, cloſe-grained fracture, and moderate ſpecific gravity. It is rather more difficult of fuſion than copper; does not eaſily become calcined; and its calx is of ſo deep a blue colour as to appear black. The moſt remarkable and moſt valuable property of this metallic ſubſtance is, that its calx, when fuſed with borax, or with alkali and ſand, produces a blue glaſs, known by the name of ſmalt. The action of air ſoon tarniſhes cobalt; but water has little or no effect upon it.

Concentrated and boiling vitriolic acid, diſtilled nearly to dryneſs, combines with this ſemi-metal. Much vitriolic acid air flies off; and the cobalt is in part calcined, and in part converted into a cryſtallizable ſalt, ſoluble in water, and precipitable by lime and by alkalis in the form of a roſe-coloured powder or calx. Diluted vitriolic acid acts upon the calx of cobalt, and forms the ſame ſalt.

Nitrous acid diſſolves cobalt by the aſſiſtance of a moderate heat. Nitrous air is diſengaged, and the ſolution affords deliqueſcent cryſtals by evaporation, which do not detonate on ignited coals, but boil up and leave a red calx. Lime and the alkalis precipitate the ſolution; and, if the alkali be added in exceſs, it diſſolves the precipitate.

The marine acid has ſcarcely any action on cobalt, unleſs it be boiling; in which caſe it diſſolves a ſmall portion. It diſſolves the calx more readily, with which it forms a red brown fluid, that becomes green when heated. This ſolution affords deliqueſcent cryſtals by evaporation.

Aqua regia diſſolves cobalt more eaſily than the marine, though not ſo readily as the nitrous acid. This ſolution is well known as one of the moſt celebrated ſympathetic inks afforded by chemiſtry. If it be diluted with a ſufficient quantity of water to prevent its action upon paper, and then uſed to write with, the letters are inviſible as ſoon as the clear ſolution has become dry; but, if the paper be held to the fire for a ſhort time, they appear of a fine green colour; which again diſappears by removing it, and ſuffering it to cool again. If the heat be continued too long after the letters appear, it will render them permanent. This effect ſeems to be analogous to that which obtains in the marine ſolution: but none of the efficient cauſes of change of colour in this, or any other chemical phenomenon, have been hitherto explained.

The acid of borax does not act immediately on cobalt, in the humid way: but borax itſelf, added to either of the foregoing ſolutions, effects a decompoſition by double affinity; the alkali uniting with the ſolvent acid, while the acid of borax ſeizes the cobalt, and forms a ſcarcely ſoluble compound, which falls down.

The acid of ſugar precipitates cobalt from its ſolutions, in the form of a pale roſe-coloured powder.

Whether

Whether alkalis or earths combine with this metal directly, by the intervention of water, has not been determined.

Cobalt does not act on neutral ſalts in general. It detonates feebly with nitre, when projected into a red hot crucible, with twice or thrice its weight of that ſalt. The metal becomes calcined by the action of the nitre; but the changes in both ſubſtances require farther examination.

Sal ammoniac is not decompoſed by cobalt.

Sulphur does not unite with cobalt but with difficulty. Liver of ſulphur combines more readily with it. The action of phoſphorus, or its acid, on this ſubſtance, remains to be aſcertained.

This ſemi-metal unites by fuſion with moſt of the metals and ſemi-metals, as has before been noticed. Silver, lead, and biſmuth, do not mix with it; and zinc does not but with great difficulty.

Cobalt is found native in alloy with arſenic and iron, and of a ſteel-grained appearance when broken; or in a calciform ſtate, of a black colour, either pulverulent or indurated; or combined with arſenical acid, in the flowers of cobalt, of a red colour; or, laſtly, united to ſulphur and iron, with or without arſenic, of various ſhades of redneſs. Biſmuth, nickel, and other ſubſtances are contained in theſe ores. They may in general be diſtinguiſhed by ſolution in aqua regia; with which, after dilution with water, they form the ſympathetic ink above deſcribed.

The native cobalt, and its calciform or ſulphureous ores, may be examined by ſolution in aqua regia, and evaporation to dryneſs; after which, the calcined cobalt may be diſſolved by vinegar. When this calx is precipitated by mild mineral alkali, the regulus may be accounted for, by allowing one hundred grains for every hundred and ſixty grains of precipitate. The other component parts of the reſidue, not taken up by the vinegar, may be aſcertained by the uſual methods. The red arſenical cobalt ore, which contains arſenical acid, may be decompoſed by vitriolic acid; and the diſengaged arſenical acid will be taken up by highly rectified ſpirit of wine; after which, the combination of vitriolic acid and cobalt may be diſſolved in water, and precipitated by mild alkali: or the ore itſelf may be diſſolved in water, ſharpened by an acid; and the calx be then precipitated by the alkali.

In the dry way, the ores of cobalt, after previous pounding, waſhing, and roaſting, may be fuſed with three times their weight of black flux, in a lined and covered crucible, by the heat of a ſmith's forge. The tingeing power of cobalt ores may be aſſayed by fuſion with three parts of fixed alkali, and five of powdered flint or glaſs. The alkali muſt be put firſt into the crucible, next the flint, and, above all, the roaſted ore. When cobalt ores, containing biſmuth, are reduced, this ſemi-metal uſually occupies the lower part of the crucible, and may be ſeparated from it by a blow with a hammer; or at leaſt by eliquation, or melting, on account of its greater fuſibility.

Cobalt is found in ſeveral parts of Europe, but moſt plentifully on the ſouthern border of France and in Saxony. The ore is uſually broken into pieces about the ſize of a hen's egg, and the ſtony parts picked out. The ſorted mineral is then pounded in mills, and ſifted through wire ſieves. By waſhing in water, the lighter parts are carried off; and the remainder is calcined in a furnace reſembling an oven, wherein it is heated by the action of the reverberated flame

of

of wood which plays upon it. In this ſituation, it is occaſionally ſtirred with long iron rakes; and emits fumes, conſiſting chiefly of arſenic, which is collected in a long horizontal chimney, built for that purpoſe. If the ore contains biſmuth, this fuſible ſemi-metal is collected at the bottom of the furnace. The cobalt, after a ſufficient torrefaction, remains in the form of a dark grey calx, called zaffre. The zaffre of commerce always contains twice or thrice its weight of powdered flints. The flint is pulverized for this and other purpoſes by means of previous ignition, and quenching in water, which renders it friable. Smalt is a blue glaſs, compoſed of one part of the calcined cobalt, fuſed with two of the flint powder, and one of pot-aſh.

The uſe of this metallic ſubſtance is confined chiefly to the production of the blue glaſs for enamels, and other purpoſes. Powder and ſtone blue, uſed by laundreſſes, is a preparation made by the Dutch from the coarſe ſmalt.

COCHINEAL was at firſt ſuppoſed to be a grain, but naturaliſts ſoon diſcovered that it was an inſect. It is brought to us from Mexico, where the inſect lives upon different ſpecies of the opuntia. The body of the female is flat on the belly, and hemiſpherical on the back, and marked with tranſverſe wrinkles. The ſkin is of a dark brown, the mouth is a tubular point which iſſues from the ſide of the thorax; it has ſix very ſhort brown legs and no wings: the body of the male is rather long, of a deep red colour, and covered with two wings extending horizontally, and croſſing a little upon the back: it has two ſmall antennæ on the head, and ſix legs, which are larger than thoſe of the female; it has not a direct flight, but flutters, hopping very ſeldom: its life, which is only of a month's duration, terminates by its amours; and the fecundated female lives a month longer, and dies after parturition: the female is ſometimes oviparous and ſometimes viviparous. The young females when brought forth diſperſe themſelves upon the joints of the opuntia, where they remain fixed by their trunk (trompe) till the end of their life.

Two ſorts of cochineal are gathered at Mexico, the ſylveſtris, there known by the Spaniſh name grana ſylveſtra, and the fine, or grana fina, called alſo meſteque, from the name of a province in Mexico, and which are bred upon the nopal. The firſt is ſmaller, and covered with a cottony down, which increaſes its weight with a ſubſtance which is uſeleſs in dying: an equal weight of it therefore gives leſs colour, and is of a lower price than the fine cochineal; but theſe diſadvantages are perhaps compenſated by its being reared with greater facility, and at leſs expence, and even by the effects of its down, which enables it better to reſiſt rain and ſtorms.

The coch. ſylveſt. when bred upon the nopal, loſes part of its tenacity, and ſome of its cotton, and acquires double the ſize it has on the other ſpecies of opuntia. It is therefore to be hoped that it might be improved by a continued attention to the rearing of it, and would approach more and more to the fine cochineal.

M. Thieri de Menonville was led by his patriotic ſpirit and perſonal courage to expoſe himſelf to imminent danger, in going to obſerve the mode of rearing the cochineal in Mexico, in order to obtain from thence that valuable production, wherewith he might enrich the colony of St. Domingo. He brought back with him both ſpecies of cochineal, and nopals, the kind of opuntia which affords the beſt food for theſe inſects.

Upon

Upon his return, he employed himſelf in the cultivation of the nopal and different kinds of opuntia, and in rearing the two ſpecies of cochineal; but death cut off that excellent citizen, and the fine cochineal ſoon periſhed.

When he returned to St. Domingo, he diſcovered the cochinilla ſylveſtris upon a kind of opuntia called péreſchia, or patte de tortue, which grows there. ceſsfully in rearing this ſpecies of cochineal; M. Rouler employed himſelf ſuc- des Philadelphes*, who do not loſe ſight of that object, and have publiſhed a poſthumous work of M. Thieri de Menonville, which contains very minute inſtructions with regard to every thing that reſpects the cultivation of the nopal, and the other ſpecies of opuntia that may be ſubſtituted for it more or leſs ſucceſsfully, for breeding or rearing the cochineal.

Two months after the females, which have been reſerved, are ſown upon the nopal, the young cochineals are obſerved to iſſue from them; and then is the proper ſeaſon for gathering them: they are killed by immerſion in boiling water. The hot iron plates or ovens which are ſometimes employed may injure the cochineal by being too hot. When taken out of the water, they are carefully dried by free expoſure to the ſun. They loſe nearly two thirds of their weight in drying.

When the fine cochineal is dry, it muſt be paſſed through a ſieve ſufficiently coarſe to allow it to go through, but capable of retaining the down and cotton of the larvæ of the males. Theſe are kept apart and ſold ſeparately, or with the cochinilla ſylveſtris.

Fine cochineal, which has been well dried and properly kept, ought to be of a grey colour inclining to purple. The grey is owing to a powder which covers it naturally, a part of which it ſtill retains: the purple tinge proceeds from the colour extracted by the water in which it has been killed.

Cochineal will keep a long time in a dry place. Hellot ſays, that he tried ſome one hundred and thirty years old, and found it produce the ſame effect as new.

The decoction of cochineal is of a crimſon colour, inclining to violet.

A ſmall quantity of vitriolic acid made this liquor aſſume a red colour, inclining to yellow, and a ſmall quantity of a beautiful red precipitate was formed.

Muriatic acid produced nearly the ſame change in the colour, but no precipitate.

Solution of tartar changed the liquor to a yellowiſh red. A little precipitate of a pale red colour formed ſlowly: the ſupernatant liquor remained yellow; but, on pouring in a little alkali, it became purple. The ſmall quantity of precipitate was quickly diſſolved by the alkali, and the ſolution was purple. Solution of tin formed a roſe-coloured precipitate with the yellow liquor.

Solution of alum brightened the colour of the infuſion, and gave it a redder hue; a crimſon precipitate was formed, and the ſupernatant liquor retained a crimſon colour, ſomewhat reddiſh.

Alum and tartar mixed produced a brighter colour, more lively, and inclining to a yellowiſh red. A precipitate was formed, but much leſs abundant, and much more pale than in the preceding experiment.

* Now the Royal Society of Arts and Sciences at Cape François.

Solution of tin produced a copious ſediment of a beautiful red. The liquor remaining above it was as clear as water, and ſuffered no change of colour on adding alkali.

Having poured in a ſolution of tartar, and after that a ſolution of tin, a precipitate of a roſe colour, inclining to black, was formed more quickly than in the foregoing experiment, and a little yellow.

Solution of common ſalt rendered the colour ſomewhat deeper, but did not make the liquor turbid.

Sal ammoniac gave a purple tinge, without occaſioning any precipitate.

Glauber's ſalt produced no perceptible change in the liquor.

Having boiled a little cochineal with half its weight of tartar, the liquor was more inclining to red, and had a colour much leſs deep than that obtained from an equal quantity of cochineal without tartar; but the former gave a more abundant precipitate with ſolution of tin, and its colour was more roſy; ſo that tartar favours the ſolution of the colouring part of the cochineal; for, though the colour of the ſolution is leſs deep, the precipitate produced from it by ſolution of tin is of a deeper and more roſy hue. This experiment deſerves notice, in judging of the influence of tartar in dying ſcarlet.

Martial vitriol formed a brown violet precipitate. The ſupernatant liquor remained clear, with a tinge of feuille-mort.

Vitriol of zinc formed a deep violet precipitate. The ſupernatant liquor remained clear and colourleſs.

Sugar of lead produced a purple violet precipitate, leſs deep than the preceding. The ſupernatant liquor remained limpid.

Vitriol of copper produced a violet ſediment, which formed ſlowly. The liquor remained clear, and of a violet colour.

If the extract which decoction of cochineal affords on evaporation be digeſted in alcohol, the colouring part diſſolves, and leaves a reſiduum of the colour of wine-lees, of which freſh alcohol cannot deprive it. This reſiduum, analyſed by fire, affords the common products of animal ſubſtances.

The alcohol of cochineal leaves on evaporation a tranſparent reſiduum of a deep red, which when dry has the appearance of a reſin. This alſo, if diſtilled, yields the product of animal ſubſtances; which ſhews that the colouring matter is an animal production.

Yet the decoction of cochineal does not eaſily putrefy. Berthollet has kept ſome of it more than two months, both in an open veſſel and in a bottle corked. At the end of that time the former ſhewed no ſigns of putrefaction, the latter had a ſlight putrid ſmell. The firſt grew turbid in a few days, and left a brown violet ſediment on the filter: the ſecond preſerved its tranſparency a long time, and probably loſt it only from the effect of an incipient putrefaction, or rather of a ſlight combuſtion, produced by means of a little vital air, probably united with the red particles of the cochineal. The colour of each had become crimſon; but that of the former was more weak, becauſe a greater part of the colouring matter had precipitated, in conſequence of the effects produced on it b the air.

A diſtinguiſhing characteriſtic between cochineal and madder may be obſerved in the manner in which they are acted on by the re-agents. Both receive a yellow colour from acids; but if the colouring matter of cochineal be ſeparated by

by a ſubſtance which precipitates it from the acid liquor, it re-appears with its natural colour little altered; whilſt that of madder, treated in the ſame manner, retains a yellow or fawn tinge. Hence mordants abounding in acid, as ſolution of tin, are much more ſucceſsfully employed with cochineal than with madder. The cauſe of this probably is, that the colouring matter of madder united with oxyd of tin retains a portion of acid, whilſt that of cochineal combined with it retains none, or a much ſmaller quantity.—Berthollet on Dying.

COCKLE. A Corniſh mineral term applied to various ſubſtances, but moſt generally to the ſubſtance called ſchorl or ſhirl, from the German, which ſee.

COHESION. The power by which the parts of bodies become attached to each other, and form conſiſtent maſſes. We know ſcarcely any thing concerning attraction but its effects, there being very few inſtances indeed wherein we can conſider ourſelves as authorized to refer this property to any more remote cauſe deducible by our reſearches. The various kinds of attraction have been claſſed relative to their effects, and conſidered as diſtinct, and in a certain ſenſe independent properties. It has however been made a queſtion by chemiſts of undoubted ſagacity, whether all attractions, and more particularly the coheſive and chemical attractions, ought not to be referred to one general property of matter, modified by variations in the figures, relative diſtances, &c. of bodies. *See* ATTRACTION.

COHOBATION. It is frequently required in chemical operations, that a ſubſtance ſhould be for a long time boiled, or digeſted in a volatile fluid conſiderably heated. This neceſſarily ſuppoſes a great loſs of the fluid, if the operation be performed in an open veſſel. To prevent this the ancient chemiſts employed a kind of ſtill, called a pelican. The head of this veſſel was provided with two beaks, which by a gradual incurvation returned into the body, and conveyed thither whatever volatile matter had riſen into the head, and there became condenſed. The views and practices of the moderns do not require theſe long digeſtions; but many valuable experiments of Prieſtley and others, of the nature of repeated diſtillation, have been made by a ſimpler apparatus. A glaſs tube, three or four feet in length, ſupplies the place of the pelican. A mineral acid water, or any other requiſite fluid, is put into the tube, in ſuch a quantity as to occupy an inch or more of its lower end; the upper end is then hermetically ſealed, and heat applied to the lower by a ſand bath. The fluid partly riſes, and is partly changed in other reſpects by the heat. The vapours as they arrive towards the upper part of the tube become condenſed, and return again to the lower in a kind of circulation down the cooler ſide of the veſſel. In this way Scheele has ſhewn that the pretended converſion of water into earth by repeated diſtillation, is in fact nothing more than an abraſion or decompoſition of the glaſs veſſels; and Prieſtley has made a variety of experiments on the mineral acids.

COKE. *See* COAL.

COLCOTHAR. The brown red calx of iron which remains after the diſtillation of the acid from martial vitriol: it is uſed for poliſhing glaſs and other ſubſtances by artiſts, who call it crocus, or crocus martis.

COLD. The privation of heat. *See* HEAT.

COLOPHONY. Colophony, or roſin, is the reſinous reſiduum after the diſtillation of the light oil from turpentine. It has alſo the properties

of other reſins, and the ſame principles may be obtained from it by analyſis.

COMBINATION. When two bodies unite together in ſuch a manner as that moſt of the original properties of the bodies reſpectively diſappear, and the compound exhibits new properties not immediately deducible from thoſe before exiſting, the bodies are ſaid to be combined together. Combination is therefore the moſt intimate union of bodies, and is to be diſtinguiſhed from the groſſer union called mixture.

COMBUSTION. There is a remarkable diſtinction in bodies with regard to the effects of heat upon them. Some bodies will admit of being heated to ſuch a degree as even to become luminous or red hot without any permanent or conſiderable change of their properties or component parts; and as ſoon as the communication of heat ceaſes, the bodies immediately begin to cool. On the other hand there are a great number of bodies, which, when heated with acceſs of vital air to ſuch a degree as to become luminous, undergo a change in their properties, inſomuch that their temperature even increaſes, and they continue to give out heat until the general ſtate of the combination of their parts is changed. Theſe bodies are diſtinguiſhed by the name of combuſtible bodies, and the alteration produced by this apparently ſpontaneous production of heat is called combuſtion.

It muſt always have been a problem of the firſt importance in natural philoſophy to aſcertain what happens in combuſtion. The diviſion of ſubſtances into combuſtible and incombuſtible, is as ſtriking and diſtinct as any we are acquainted with; and it is a natural inference, that the one claſs of bodies muſt poſſeſs ſome general property or identical ſubſtance not to be found in the other. The philoſophy of the middle ages, probably in conſequence of their logical claſſifications, was much more diſpoſed to attach itſelf to ſubſtances than habitudes or properties. It is leſs to be wondered at, therefore, that Beccher and Stahl ſhould have aſſigned a ſubſtance eminently combuſtible, or fire itſelf, as reſident in all combuſtible bodies, and occaſioning the difference between them and other bodies, inſtead of enquiring whether the general effect might not have ariſen from ſome effect of the chemical affinities. Modern chemiſts have however very amply and ſucceſsfully maintained this laſt doctrine. Something like party has ariſen in the diſcuſſion of this great queſtion. It is perhaps the lot of humanity that apathy ſhould attend abſolute impartiality, or the abſence of prejudice. It is probable that the bigotry of the maintainers of what is now frequently called the ancient chemiſtry, and the impetuoſity of the cultivators of the new, may have occaſioned a more complete diſcuſſion of the ſubject, than philoſophers whoſe paſſions were leſs animated might have taken the trouble to have made. But there is one evil amongſt others which attends the ſpirit of party, namely, that almoſt every man of ſcience will be diſpoſed to rank himſelf on the one or the other ſide, inſtead of adhering to that degree of neutrality which the pure facts might otherwiſe demand. A writer is expected to give an account of his chemical creed, and of courſe becomes leſs credible to readers of the oppoſite party, to which he has not attached himſelf. And on the other hand, the man who deſpiſes party, and keeps his opinion to himſelf, is ſuppoſed to be actuated by fears of the reigning prejudices of the country he lives in; which, if real, would do little credit to his ſpirit and principles as a defender and propagator of truth. Thus circumſtanced like every other chemical writer, decidedly

cidedly averſe to giving up any part of that claim to impartiality which every cultivator of moral or natural philoſophy ought to maintain, and at the ſame time unwilling to pay any compliment to the prejudices either of ancient or modern chemiſts, it appears neceſſary to ſay, that, as far as my knowledge extends, I find the modern or anti-phlogiſtic doctrine much more ſimple in its application to the facts, and conſequently much more probable than the ſyſtem of Stahl: and I believe that any chemiſt, who will take the trouble to acquire the habit of applying the one doctrine as readily as he does the other, will not fail to arrive at the ſame concluſion. After this preface, I ſhall proceed to a ſhort ſtatement of the two doctrines as applied to combuſtion in general.

The modern maintainers of phlogiſton, or the principle of inflammability, do not teach exactly the ſame doctrine as Stahl. This chemiſt ſuppoſed combuſtion to conſiſt in the eſcape of fire from bodies. Various facts have compelled the moderns to modify this poſition. The moſt generally received ſtatement is, that a ſubſtance called phlogiſton, and very ſtrongly attractive of vital air, reſides in all combuſtible bodies; that a certain degree of heat weakens the adherence between phlogiſton and the combuſtible ſubſtance, and conſequently diſpoſes it to a more ſpeedy union with the vital air of the atmoſphere; that the capacity of vital air for heat is diminiſhed by this union, and conſequently an increaſe of temperature follows, which ſerves to accelerate the diſengagement of more of the phlogiſton; and in this way heat continues to be extricated until the body has become dephlogiſticated, or incombuſtible.

The modern or anti-phlogiſtic theory is exactly the ſame, excepting that inſtead of ſuppoſing combuſtible bodies to contain a principle of inflammability which attracts the vital air of the atmoſphere, it infers that the body itſelf attracts and combines with that air; and as no difficulty enſues from this ſtatement, it ſeems clear that the phlogiſton is redundant and unneceſſary in accounting for the effects.

The conſideration of theſe doctrines and their conſequences embraces nearly the whole ſcience of chemiſtry; but the reader may more eſpecially recur to the articles, ACIDS, METALS, PHLOGISTON, and HEAT.

CONCENTRATION. This term is uſed to denote the privation of a part of the water uſually contained in certain fluids, more particularly ſaline ſolutions. Thus, by evaporation of part of the water of a ſolution of ſea ſalt, we obtain a concentrated brine; by evaporation in a nearly cloſed veſſel, or by diſtillation, part of the water of vitriolic acid is driven off, and the remainder is concentrated vitriolic acid. Thus, again, if vinegar be expoſed to freeze, the aqueous part congeals firſt, leaving the concentrated vinegar behind.

CONDENSATION. The approach of the particles of a body to each other, ſo as to cauſe the whole to occupy leſs ſpace than before. It is moſt commonly applied in chemiſtry to denote the tranſition from the vaporous or aërial to the ſolid ſtate, as happens in diſtillation, ſublimation, &c.

CONGELATION. The formation of ice. The term is applied in general to every tranſition from the fluid to the ſolid ſtate. Thus we ſay the congelation of acids of ſulphur, of oils, of metals, &c.

CONE, MELTING. This is a hollow cone formed of copper or of braſs, with a handle, and with a flat bottom adjoining to the apex of the cone, upon which it is intended to reſt. Its uſe is to receive a maſs of one or more metals melted together and poured into it. This maſs, when cold, may be eaſily ſhook

out of the cone from the figure of the veſſel. Alſo if a melted maſs, conſiſting of two or more metals, or other ſubſtances not combined together, be poured into this veſſel, the conical figure facilitates the ſeparation of theſe ſubſtances according to their reſpective denſities. The cone ought to be well heated before the melted maſs is poured into it, that no moiſture may be contained, by which a dangerous exploſion might be occaſioned. It ought alſo to be greaſed internally with tallow, to prevent the adheſion of the fluid matter.

CONTRAYERVA. The leaves of this plant are ſaid to afford a poiſon employed by Indians for poiſoning arrows, to which poiſon the root of the ſaid plant is ſaid to be an antidote. From an ounce of the root, Neumann extracted with water three drams and half a ſcruple; and from the ſame quantity with ſpirit of wine, five ſcruples and two grains.

COPAL, improperly called gum copal, is a hard, ſhining, tranſparent, citron-coloured, odoriferous, concrete juice of an American tree, but which has neither the ſolubility in water common to gums, nor the ſolubility in ſpirit of wine common to reſins, at leaſt in any conſiderable degree. By theſe properties it reſembles amber. It may be diſſolved by digeſtion in linſeed oil with a heat very little leſs than ſufficient to boil or decompoſe the oil. This ſolution, diluted with ſpirit of turpentine, forms a beautiful tranſparent varniſh, which, when properly applied and ſlowly dried, is very hard and very durable. This varniſh is applied to ſnuff-boxes, tea-boards, and other utenſils. It preſerves and gives luſtre to paintings, and greatly reſtores the decayed colours of old pictures by filling up the cracks and rendering the ſurfaces capable of reflecting light more uniformly.

COPPER is a metal of a peculiar reddiſh brown colour; hard, ſonorous, very malleable and ductile; of conſiderable tenacity, and of a moderate ſpecific gravity. At a degree of heat far below ignition the ſurface of a piece of poliſhed copper becomes covered with various ranges of priſmatic colours, the red of each order being neareſt the end which has been moſt heated; an effect which muſt doubtleſs be attributed to calcination, the ſtratum of calx being thickeſt where the heat is greateſt, and growing gradually thinner and thinner towards the colder part. A greater degree of heat calcines it more rapidly, ſo that it contracts thin powdery ſcales on its ſurface, which may be eaſily rubbed off; the flame of the fuel becoming at the ſame time of a beautiful blueiſh green colour. In a ſtrong white heat, nearly the ſame as is neceſſary to melt gold or ſilver, it melts, and exhibits a blueiſh green flame; by a violent heat it boils, and is volatilized partly in the metallic ſtate.

Copper ruſts in the air; but the corroded part is very thin, and preſerves the metal beneath from further corroſion.

The vitriolic acid, when concentrated and boiling, diſſolves copper. A brown thick fluid, containing calx of copper and a portion of the calx combined with vitriolic acid, is found at the bottom of the ſolvent. If water be added to this, it forms a blue ſolution of copper, which by evaporation affords blue cryſtals, that require about four times their weight of water to diſſolve them. This ſolution lets fall a calx of copper of a green colour by long expoſure to the air.

The ſolutions of copper in vitriolic acid are ſlightly cauſtic. Magneſia, lime, and the fixed alkalis, precipitate the metal from them in the form of calx. Volatile alkali precipitates all the ſolution of copper; but rediſſolves the calx, and produces a deep blue colour. Copper is precipitable from moſt of its ſolutions, in the metallic ſtate, by the addition of iron: a clean plate of iron ſoon

becomes

becomes covered with a coating of copper, when immerſed in the ſolution: hence the volatile alkali and the application of iron are conſidered as the teſts of the preſence of copper. There are certain mineral waters in Hungary, Sweden, Ireland, and in various parts of England, which contain vitriol of copper, and from which it is precipitated by the addition of pieces of old iron.

Nitrous acid diſſolves copper with great rapidity, and diſengages a large quantity of nitrous gas. Part of the metal falls down in the form of a calx; and the filtrated or decanted ſolution, which is of a much deeper blue colour than the vitriolic ſolution, affords cryſtals by ſlow evaporation. This ſalt is deliqueſcent, very ſoluble in water, but moſt plentifully when the fluid is heated. Its ſolution, expoſed to the air in ſhallow veſſels, depoſites a calx of a green colour. Lime precipitates the metal of a pale blue; fixed alkalis of a blueiſh white. Volatile alkali throws down blueiſh flocks, which are quickly rediſſolved, and produce a lively blue colour in the fluid.

Marine acid does not readily diſſolve copper, unleſs it be concentrated and boiling. The ſolution is of a deep brown colour; but on ſtanding for ſome time it depoſites a ſediment, and becomes green. By careful evaporation it yields cryſtals; or when inſpiſſated, it affords a greeniſh maſs, which deliqueſces in the air, is readily diſſolved in water, gives a green tincture to ardent ſpirit, melts in a gentle heat, takes fire from a candle, and burns with a blue flame. The marine acid diſſolves the calces of copper more readily than the metal itſelf; but the ſolution does not differ from the foregoing.

Vegetable acids diſſolve copper ſlowly; but in conſiderable quantity, if reſpirable air be preſent. In this, as in a number of other metallic ſolutions, it appears that the diſpoſition of the air to calcine the metal is greatly aſſiſted by the elective attraction of the acid for the metallic calx. Vinegar does not diſſolve copper when boiling, becauſe the ſteam prevents the acceſs of the air; but the ſame acid ſtanding for a day in a copper veſſel, will contract a dangerous metallic impregnation. This circumſtance accounts for the unhappy conſequences produced in ſome inſtances by copper veſſels, which in other caſes have produced no noxious effects. Confectioners boil pickles, and even lemon-juice, in clean copper veſſels, without obſerving any bad taſte or noxious conſequence to follow. We cannot however avoid heartily concurring in the general opinion which now prevails, in the rejection of copper veſſels for culinary purpoſes.

Verdigris is a calx of copper, prepared in large quantities near Montpellier in France by ſtratifying copper plates with the huſks of grapes which remain after the juice has been preſſed out. Theſe ſoon become acid, and corrode the copper. A ſolution of this calx in diſtilled vinegar affords permanent cryſtals, improperly called diſtilled verdigris.

Fixed alkalis have ſome action on copper, with which they form a light blue ſolution. This, as well as the volatile alkaline ſolution, appears to ſucceed better in the cold than by the aſſiſtance of heat; for the ſame reaſon as the cold acetous acid acts upon copper; namely, the facility with which the metal is calcined by the acceſs of air.

Volatile alkali diſſolves copper with much greater rapidity than fixed alkalis, whether it be in the metallic or calciform ſtate, and forms a beautiful blue ſolution. This fluid has long attracted the notice of chemiſts, on account of its becoming colourleſs in cloſed veſſels; and recovering its colour, which gradually extends from the ſurface downwards, when the veſſel is opened. This

effect is explained by the ſuppoſition, that the perfect ſolution of calx of copper in volatile alkali is colourleſs when the alkali is in exceſs; but that it is blue when it abounds with calx of copper: and accordingly it is found that the loſs of colour on keeping the veſſel cloſed for ſome time, and its re-appearance on opening the veſſel, do not ſucceed with old ſolutions, which are permanently blue.

The air calcines more perfectly a portion of the ſuſpended copper, which gives a blue colour to the fluid until it has more intimately combined with the alkali. If this combination be made in the cloſed veſſel, the colour diſappears; if it be made in the open veſſel, the calcination of another portion goes on, and continues until the alkali is ſaturated, and can combine with no more: ſo that the laſt portion of perfect calx, which cauſes the blue colour, does not ſeem to have entered into ſo intimate a combination, for want of an exceſs of alkali. The alkali does not take up any conſiderable quantity, when applied to copper filings; but it diſſolves much more of the calces of copper. The ſolution does not very readily afford cryſtals.

Oils do not ſeem to act upon copper until they become rancid, in which caſe their diſengaged acid corrodes the copper, and the oil aſſumes a blueiſh green colour. Verdigris is ſoluble in ardent ſpirit. Copper, in the metallic ſtate, does not unite with earths or alkalis in the dry way. Its calces enter into the compoſition of glaſs. In general it does not act on the neutral ſalts by fuſion. Nitre detonates with it but difficultly. Filings of copper are thrown upon red hot nitre; and the reſidue is a browniſh grey calx, mixed and partly combined with vegetable alkali. If this be waſhed with water, the remaining calx may be fuſed without other addition into a deep opake brown glaſs, uſed by enamellers.

Sal ammoniac is decompoſed by copper filings. The produce which comes over conſiſts of cauſtic volatile alkali, rendered blue by a ſmall portion of copper, together with alkaline air, inflammable air, and phlogiſticated air: the reſidue conſiſts partly of marine ſalt of copper and calx. In this experiment we find that the copper detains the acid; while the volatile alkali being ſet at liberty comes over into the receiver. The inflammable and phlogiſticated air cannot ſo clearly be accounted for, as they may ariſe either from part of the alkali being decompoſed into its firſt principles, or the inflammable air may be ſupplied during the ſolution of the copper; in which caſe it will proceed from the phlogiſton of that metal, according to the hypotheſis of Stahl; or from a decompoſition of part of the water of cryſtallization of the ſal ammoniac; the pure air of which will be communicated to the copper, in order to calcine and render it ſoluble in the marine acid, while its inflammable air comes over in the elaſtic ſtate.

A ſolution of alum boiled in a copper veſſel depoſits ſome earth, and the fluid exhibits ſigns of the preſence of copper by the teſt of volatile alkali. This does not ſeem to be a perfect decompoſition of the alum; but appears to be effected by virtue of the acid, which that ſalt contains in exceſs. The neutral ſalt or alum ſaturated with its own baſis falls down, becauſe leſs ſoluble; while the exceſs of acid, forming vitriol of copper, exhibits the blue tinge when volatile alkali is added.

Copper unites very readily with ſulphur. If copper filings be mixed with flowers of ſulphur and a little water, the combination takes place; but it is much more readily effected in the dry way. This cannot be done by direct fuſion, becauſe

becauſe the ſulphur is burned at a much leſs heat than is required to fuſe the copper. It may be prepared by mixing equal parts of ſulphur and copper filings together, and expoſing them to heat gradually raiſed to ignition: or plates of copper may be ſtratified in a crucible with ſulphur, and gradually heated as before. This compound is a blackiſh grey maſs, and is uſed by dyers and callico printers: it is diſtinguiſhed by the name of æs veneris. Liver of ſulphur diſſolves copper both in the humid and dry way.

Phoſphorus unites with the calx of copper; or if the phoſphoric glaſs be expoſed to heat in a crucible, together with its weight of copper filings and about one quarter of its weight of charcoal, the phoſphorus which is formed combines with the copper, and forms a kind of pyrites, which changes by expoſure to air. It loſes its metallic ſtate, and aſſumes a black colour.

This metal combines very readily with gold, ſilver and mercury. It unites imperfectly with iron in the way of fuſion. Tin combines with copper, at a temperature much lower than is neceſſary to fuſe the copper alone. On this is grounded the method of tinning copper veſſels. For this purpoſe, they are firſt ſcraped or ſcoured; after which they are rubbed with ſal ammoniac. They are then heated, and ſprinkled with powdered reſin, which defends the clean ſurface of the copper from acquiring the ſlight film of calx which would prevent the adheſion of the tin to its ſurface. The melted tin is then poured in, and ſpread about. An extremely ſmall quantity adheres to the copper; which may, with great juſtice, be ſuppoſed inſufficient to prevent the noxious effects of the copper as perfectly as might be wiſhed.

When tin is melted with copper it compoſes the compound called bronze. In this metal the ſpecific gravity is always greater than would be deduced by computation from the quantities and ſpecific gravities of its component parts. The uſes of this hard, ſonorous and durable compoſition in the fabrication of cannon, bells, ſtatues, and other articles, are well known. Bronzes and bell-metals are not uſually made of copper and tin only, but have other admixtures, conſiſting of lead, zinc, or arſenic, according to the motives of profit, or other inducements of the artiſt. But the attention of the philoſopher is more particularly directed to the mixture of copper and tin, on account of its being the ſubſtance of which the ſpeculums of reflecting teleſcopes are made. *See* SPECULUM.

Copper unites with biſmuth, and forms a reddiſh white alloy. With arſenic it forms a white brittle compound, called tombac. With zinc it forms the compound called braſs, and diſtinguiſhed by various other names, according to the proportions of the two ingredients. It is not eaſy to unite theſe two metals in conſiderable proportions by fuſion, becauſe the zinc is burned or volatilized at a heat inferior to that which is required to melt copper; but they unite very well in the way of cementation. In the braſs works, copper is granulated by pouring it through a plate of iron, perforated with ſmall holes and luted with clay, into a quantity of water about four feet deep and continually renewed: To prevent the dangerous exploſions of this metal, it is neceſſary to pour but a ſmall quantity at a time. There are various methods of combining this granulated copper, or other ſmall pieces of copper, with the vapour of zinc. Calamine, which is an ore of zinc, is pounded and mixed with the divided copper, together with a portion of charcoal. Theſe being expoſed to the heat of a wind furnace, the zinc becomes revived, riſes in vapour, and combines with the copper, which it

converts into braſs. The heat muſt be continued for a greater or leſs number of hours, according to the thickneſs of the pieces of copper, and other circumſtances; and at the end of the proceſs, the heat being ſuddenly raiſed cauſes the braſs to melt, and occupy the lower part of the crucible. The moſt ſcientific method of making braſs ſeems to be that mentioned by Cramer. The powdered calamine, being mixed with an equal quantity of charcoal and a portion of clay, is to be rammed into a melting veſſel, and a quantity of copper, amounting to two thirds of the weight of the calamine, muſt be placed on the top, and covered with charcoal. By this management the volatile zinc aſcends, and converts the copper into braſs, which flows upon the rammed clay: conſequently, if the calamine contain lead, or any other metal, it will not enter into the braſs, the zinc alone being raiſed by the heat.

A fine kind of braſs, which is ſuppoſed to be made by cementation of copper plates with calamine, is hammered out into leaves, in Germany; and is ſold very cheap in this country, under the name of Dutch gold. It is about five times as thick as gold leaf; that is to ſay, it is about one ſixty-thouſandth of an inch thick.

If braſs be kept in a ſtate of ignition, with contact of air, the zinc burns, and the copper remains. Whether the zinc would quit the braſs without combuſtion, is not known; though there is little doubt but it might be driven off in cloſe veſſels.

The quantity of zinc, in good braſs, is about one third of its weight.

Copper unites readily with regulus of antimony, and affords a compound of a beautiful violet colour. It does not readily unite with manganeſe. With wolfram it forms a dark brown ſpongy alloy, which is ſomewhat ductile.

Copper is either found native, moſtly in an impure ſtate, or in the form of a calx, of a red, green, or blue colour. The native ſolutions of copper frequently impregnate calcareous earths, in which they depoſit the metal. The turquoiſe ſtone is the tooth of an animal, penetrated with the blue calx of copper. Many ores of copper contain ſulphur. Among theſe, the vitreous copper ore is of a red, brown, blue, or violet colour; ſometimes cryſtallized, but uſually ſoft enough to be cut with a knife. Some of the pyrites contain a conſiderable proportion of copper, together with iron, ſulphur, and clay. The grey copper ore is a ſulphureous combination containing arſenic; it is of a white, grey, or brown colour, heavy, and difficult of fuſion. Blendoſe copper ore is of a brown colour, hard, ſolid, compact, and granulated: it contains the metal, with ſulphur, arſenic, zinc, and iron. Some ſlates, and one ſpecies of coal, afford copper; and ſeveral waters contain this metal, diſſolved in vitriolic or marine acid.

Native copper may be aſſayed, in the humid way, by ſolution in nitrous acid. If it contain gold, this metal falls untouched to the bottom, in the form of a black powder; if ſilver, it is ſoon precipitated by more copper; if iron, by boiling the ſolution for ſome time, it is gradually calcined, and falls to the bottom.

The calciform copper ores are ſoluble in acids, and may be precipitated either by iron, which affords the copper in the metallic ſtate, or by mild alkali, which throws down 194 grains of precipitate for every 100 grains of copper.

Sulphureous copper ores may be powdered, and gently boiled to dryneſs in five times their weight of concentrated vitriolic acid. The whole, or moſt part of the ſulphur, flies off by this heat. The vitriolic ſalt of copper requires at

leaſt four times its weight of water to diſſolve it. A ſufficient quantity being therefore added, and a poliſhed iron plate boiled in the ſolution, the copper will be precipitated. If iron be found to be mixed with the precipitate, it muſt be again diſſolved, to obtain a richer ſolution. This will depoſit pure copper, if the operation be conducted as before. If it contain other metals, they may be eaſily ſeparated by ſolution in nitrous acid.

In the dry way, the ſulphureous ores of copper muſt be firſt pulverized, and ſeparated as much as poſſible from the earthy and ſtony particles, then roaſted, to ſeparate the ſulphur and arſenic; and laſtly, melted with an equal weight of M. Tillet's flux, which conſiſts of two parts pounded glaſs, one calcined borax, and one eighth of charcoal. More borax may be added if the ore be poor. Alkaline fluxes are hurtful in the fuſion of copper ores, becauſe the ſalt combines with the ſulphur, and forms hepar, which diſſolves part of the copper.

In the large way copper is roaſted in a cloſe furnace, by a ſlow fire, to ſcorify the mixtures of iron and other ſubſtances. By repeated fuſions with ſulphur and charcoal, the ſcorified metal riſes to the top, and is ſcummed off. The copper, in the great Hungarian mines, is ſaid to undergo fuſion fourteen times before it is fit for ſale. The roaſted ore in the iſle of Angleſey is deprived of its vitriolic ſalt by waſhing, and the copper is precipitated by means of old iron immerſed in the water. This precipitated copper is however but ſmall in proportion to the whole produce.

Copper is found in various parts of the world; in Spain, France, England, Norway, Hungary, Sweden, and elſewhere. The Japan copper is ſaid to be purer, and has a greater ſpecific gravity, than any other copper. The wire-drawers, who require copper of extraordinary ductility, uſe the Swediſh copper. The copper mines in England are exceedingly numerous and productive. Paris Mountain, on the iſle of Angleſey, contains a bed of ore forty feet in thickneſs, and is ſaid to produce upwards of four thouſand tons of copper annually.

The uſes of this metal are too numerous to be diſtinctly ſpecified. It has for ſome years paſt been applied with great ſucceſs and advantage for ſheathing the bottoms of ſhips; and ſeveral builders have lately endeavoured to introduce it as a covering for houſes. It is the lighteſt of all coverings; but whether it be more durable than ſlate, which is nearly as light, has not yet been aſcertained by experience.

COPPERAS. Martial vitriol is called green copperas in commerce. The vitriol of copper is called blue copperas, or frequently blue vitriol; and the vitriol of zinc is called white copperas.

CORAL and CORALLINE are ſhells of marine animals of the polypus kind, and poſſeſs the ſame chemical properties as the ſhells of oyſters and other fiſh; that is, they conſiſt of calcareous earth combined with mucilage and other animal matter.

CORK is a bark of a tree of the oak kind, very common in Spain and the other ſouthern parts of Europe. By boiling in water Neumann obtained from cork one twelfth part of its weight of extract, and by digeſtion in ardent ſpirits he obtained rather a larger quantity of reſinous matter.

Mr. Brugnatelli * has examined this ſubſtance in the more accurate methods

* The Journal de Phyſique for Auguſt 1787 is now before me, containing an extract of the author's paper, from Crell's Annals for the ſame year.

of modern chemiſtry. The cork upon which he made his experiments was white and very ſmooth. In the focus of the burning glaſs it was quickly burned with a white brilliant flame, leaving a light ſpongy coal, eaſily and almoſt totally conſumed in a crucible, the reſidue of aſhes being ſcarcely perceptible. Cork, when treated in the way of deſtructive diſtillation, was entirely or very nearly converted into inflammable air. Boiling water only ſoftened it. The action of the vitriolic and alſo of the marine acid, even when aſſiſted by heat, was ſcarcely ſenſible.

But on the contrary the mere vapours of fuming nitrous acids acted upon it, and reduced a portion into a coarſe yellowiſh and evidently ſaline powder. Mr. Brugnatelli was induced from this obſervation to diſtil them together. He put half an ounce of cork, groſsly powdered or raſped, into a tubulated retort, and poured upon it four times its weight of fuming nitrous acid. The acid ſoon became of a deep yellow colour, which it communicated to the cork, while the retort by degrees became filled with red vapours produced by the diſengagement of a large quantity of nitrous air. After the diſtillation there remained a yellow viſcid and very acid matter.

This reſidue was for the moſt part ſoluble in water; the inſoluble portion being probably that which had eſcaped the action of the nitrous acid. The ſolution was yellow, ſtrongly reddened blue vegetable colours, and had an acid though bitteriſh taſte. By evaporation of the water and repoſe in a cool place, the acid again became changed into a thick viſcid matter reſembling wax, and capable of being kneaded between the fingers.

This acid is ſoluble in ardent ſpirit, to which it communicates a yellow colour, inclining to green. Upon ignited coals it does not take fire, but emits a diſagreeable ſmell like burned wood, at the ſame time that it becomes converted into coal, and at laſt into dark-coloured aſhes. The acid of cork unites with all the alkalis and earths. With the mild vegetable alkali it effervesces, and forms a thick deep yellow maſs, which cryſtallizes by cooling. This maſs is ſoluble in water, and in the three ancient mineral acids, but not in vinegar or ardent ſpirit.

Like the acid of ſugar, this acid exhibits a peculiar affinity to lime. It likewiſe acts upon metallic ſubſtances.

CORK, FOSSIL, (SUBER MONTANUM). This name is given to a ſtone which is a ſpecies of amianthus, conſiſting of flexible fibres looſely interwoven, and ſomewhat reſembling vegetable cork. It is the lighteſt of all ſtones. By fire it is fuſible, and forms a black glaſs. It poſſeſſes the general properties of amianthus.

CORO-SHUT MARLE. A kind of marle of a brown colour mixed with chalk and blue veins.

CORROSIVE SUBLIMATE. A combination of mercury with dephlogiſticated or aerated marine acid. *See* MERCURY.

COUNTRIES. An Engliſh mine term for the ſides or encloſures of a vein or load of ore: *e. g.* the country of the lead is limeſtone, killas, &c. &c.

CREAM OF LIME. When lime water is expoſed to the air, a portion of aerial acid or fixed air combines with the lime near the ſurface, and converts it into chalk, or mild calcareous earth, which firſt forms a pellicle at the top, and afterwards falls down. This ſubſtance, which is either not at all ſoluble in water,

or

or much leſs ſo than lime, is ſeparated on that account. The term is at preſent ſeldom met with.

CREAM OF MILK. A portion of milk which riſes to the ſurface of the fluid by repoſe: moſt probably in conſequence of an incipient fermentation. It contains all the butter, ſome of the cheeſe, together with a portion of the other principles of the milk. *See* BUTTER *and* MILK.

CREAM OF TARTAR. The ſalt called cream of tartar, and cryſtals of tartar, conſiſts of tartar purified by the uſual chemical methods. This manufacture is chiefly carried on at Montpellier, and at Venice. The object to be accompliſhed conſiſts in depriving the crude tartar of an abundant mucilaginous principle.

The following is the proceſs uſed at Montpellier, as given by Chaptal. The tartar is diſſolved in water, and ſuffered to cryſtallize by cooling. The cryſtals are then boiled in another veſſel, with the addition of five or ſix pounds of the white argillaceous earth of Murviel to each quintal of the ſalt. After this boiling with the earth, a very white ſalt is obtained by evaporation, which is known by the name of cream of tartar.

M. Deſmaretz has informed us (Journal de Phyſique 1771) that the proceſs uſed at Venice conſiſts, 1ſt, in drying the tartar in iron boilers; 2dly, pounding it and diſſolving it in hot water, which by cooling it affords purer cryſtals; 3dly, redisſolving theſe cryſtals in water, and clarifying the ſolution by whites of eggs and wood aſhes.

The proceſs of Montpellier is preferable to that of Venice. The addition of the aſhes introduces a foreign ſalt, which alters the purity of the product.

Cream of tartar cryſtallizes in tetrahedral priſms cut off ſlantwiſe.

This ſalt is uſed by the dyers as a mordant; but its greateſt conſumption is in the north, where it is uſed at table as a ſeaſoner.

CRIMSON. *See* DYING.

CROCUS. The yellow or ſaffron-coloured calces of iron and copper have been called crocus martis and crocus veneris. Theſe terms are now ſeldom met with in the writings of philoſophical chemiſts, though they ſtill are retained in various diſpenſatories.

CRUCIBLE. A pot or veſſel formed either of earth, of plumbago, or of ſome ſuitable metal. It is uſed for fuſions, cementations, and other operations in the dry way. *See* APPARATUS.

CRYSTAL. This word is uſed extenſively to denote thoſe portions of bodies which have aſſumed a ſymmetrical form at the time of acquiring the ſolid ſtate. Thus we have cryſtals of ſalts, of metals, of earths, and of every other ſubſtance that poſſeſſes a conſiderable degree of ſimplicity in its compoſition. It is likewiſe uſed as the name of various ſubſtances to which we ſhall proceed.

CRYSTAL, FACTITIOUS. The very fine clear glaſſes made in imitation of precious ſtones, are ſometimes called factitious cryſtals, but much more commonly paſtes. Our opticians and other artiſts diſtinguiſh the denſe white glaſs, which contains much calx of lead, by the name of cryſtal glaſs, and frequently enough by that of white flint. *See* GLASS.

CRYSTAL, MINERAL. In the ancient diſpenſatories we find a formula for making a ſalt under this name, by fuſing nitre, projecting a little ſulphur thereon, and afterwards caſting it into cakes. It is not neceſſary to give any detail of the imaginary advantages ſuppoſed to be obtained by treating nitre in this manner. The cryſtal mineral will vary according to the management. Part

of

of the nitrous acid may be decompoſed by the heat, and part will be decompoſed by the detonation. The ſulphur will be acidified, and will combine with the portion of diſengaged alkali. The cryſtal mineral will therefore conſiſt of nitre contaminated with a ſmall quantity of vitriolated tartar, and is not worth the trouble of making, becauſe pure nitre will anſwer every medical purpoſe to which this might be applied.

CRYSTAL, ROCK. The pureſt ſpecimen of ſiliceous earth. This is either colourleſs and cryſtallized in hexagonal pyramids, and then called mountain cryſtal, or in various other forms. Its ſpecific gravity is from 2,65 to 2,7. Its texture lamellated, and frequently ſhattered. The application of heat, unleſs extremely gradual, cauſes it to crack and loſe its tranſparency. Some of theſe cryſtals have been found to conſiſt of pure ſiliceous earth. Bergman extracted about ſix of argillaceous, and one of calcareous earth, from the 100 parts of theſe cryſtals. The moſt violent heat of a furnace has not been found to diminiſh the weight or hardneſs of rock cryſtal; but profeſſor Errhmann fuſed it by flame, urged with a ſtream of vital air.

The formation of cryſtal has much engaged the attention of chemiſts. There ſeems to be little doubt that this earth is ſuſpended in water, moſt probably, by a true ſolution, and afterwards depoſited in the ſame manner as other ſoluble bodies are: the only peculiarity appears to be, that ſo very large a quantity of the water is required to ſuſpend a ſmall quantity of the earth, that this laſt has eluded the attention of philoſophers. The effects of water in the extenſive operations of nature, relative to this earth, are however very conſiderable. The vaſt baſin chiefly compoſed of ſiliceous materials depoſited by the water of the prodigious fountain of Geyſer, in Iceland, deſcribed by Vontroil, affords a proof that hot water ſuſpends ſiliceous earth, and points out a ſeries of experiments to be made with Papin's digeſtor, though not yet undertaken by any one. And the obſervations of Mr. Genſſane, quoted by Chaptal in his Elements of Chemiſtry, with others of the profeſſor himſelf, prove that rock cryſtal is formed in a way not at all differing from that of calcareous ſpars. Mr. Genſſane ſhews that a quartzoſe gurh is formed by ſimple tranſudation upon ferruginous rocks, and the ſame naturaliſt has taken notice that when the gurh is worn and depoſited by water, rock cryſtals are formed. The waters which work their way through the quartzoſe rocks of the mine of Chamillat, near Planche les Mines in Franche Comté, form quartzoſe ſtalactites to the roof of the works, and even upon wood. The extremities of theſe ſtalactites, which have not aſſumed a ſolid conſiſtence, are of a granulated and cryſtalline ſubſtance, eaſily cruſhed between the fingers.

In theſe cavities, called craques by the miners, a fluid gurh is often found, and ſtill oftener cryſtals ready formed. Chaptal obſerved at Saint Sauveur, in the work of Laboiſſiere near Bramebiaou, ſeveral incruſtations of gurh on the ſide of the gallery; and theſe ſpreading incruſtations were terminated by well-formed cryſtals, wherever the wall overhung, or deviated from the perpendicular. This gurh, when handled, and minutely examined, had no other appearance than that of a ſiliceous paſte of conſiderable purity.

Bergman obtained cryſtals reſembling rock cryſtal, but not ſo hard, by diſſolving ſiliceous earth in the acid of ſpar, and leaving it to ſpontaneous evaporation. Chaptal has obſerved a fact of the ſame nature. Mr. Achard obtained a cryſtal as hard and as tranſparent as rock cryſtal by diſſolving the earth of

alum

alum in water impregnated with fixed air, the fluid filtrating very ſlowly through the bottom of a porous veſſel of baked clay. A cryſtal of this kind was ſent by him to my late friend Mr. Magellan, who exhibited it to the Royal Academy of Sciences at Paris, in the year 1778; and from whom I received it, and ſtill retain it in my poſſeſſion. Others have ſince attempted to repeat the experiment, though without ſucceſs; and there have not been wanting ſeveral writers who have queſtioned the validity of the fact, though in my opinion very raſhly; the character of this chemiſt, and the obſcurity of the ſubject, in which ſo many unheeded circumſtances might have conſpired either to produce or vary the reſults, being amply ſufficient to defend him from any imputation of ſo degrading a nature. It has been thought in particular, that a very perfect ſtate of repoſe is neceſſary for the ſucceſs of this experiment of a cryſtallization ſo extremely ſlow; and indeed if it be conſidered how greatly the phenomena of cryſtallization are influenced by the ſlighteſt agitation, and at the ſame time how conſiderable the agitations of the grounds and buildings are in great towns, it will not appear at all wonderful that the Pariſian chemiſts ſhould not have ſucceeded in attempting to repeat this experiment. Any one may ſatisfy himſelf as to theſe vibrations, by obſerving the reflection of objects in a baſin of mercury, which, however defended from the impreſſions of the external air, does not remain a moment in tranquillity, unleſs at a very great diſtance from all work-ſhops or roads where carriages paſs.

Since that time Mr. De Morveau having incloſed rock cryſtals with a bar of iron in a bottle filled with gaſeous water, perceived a vitreous point fixed to the iron, which he ſuppoſed to be a rock cryſtal formed by this operation; ſo that he conſiders iron as a neceſſary intermedium to enable the carbonic acid to diſſolve quartz.

Rock cryſtal, though the ſofteſt among tranſparent ſtones, is harder than moſt of the opake ſtones, and much harder than glaſs.

CRYSTALLIZATION. Whenever the parts of bodies are ſeparated from each other, and ſuſpended in a medium or ſolvent, in which they can freely move, they either remain at a diſtance from each other by virtue of their attraction to the ſolvent, or they come together by their own mutual attraction, and form conſiſtent maſſes. *See* ATTRACTION.

From the facts there appears to be juſt ground to conclude that the particles of bodies demand certain relative poſitions at like diſtances, in order that the energy of their attraction may be the greateſt poſſible; in a manner ſimilar to what we obſerve in the attractions of magnetiſm and electricity. This polarity of the particles deducible by mathematical reaſoning from their ſuppoſed figures, but no doubt in a great meaſure dependent on their component parts likewiſe, will cauſe the aggregate maſſes to aſſume ſome determinate figure, in ſimilar circumſtances or ſituations, and this figure will be modified in a great variety of ways accordingly as thoſe circumſtances are changed. If the particles are ſuſpended or kept fluid, either by a due quantity of ſolvent, or by heat, or by both of theſe agents, a ſeparation will enſue, whenever the quantity of the ſolvent or of the heat is diminiſhed. If this diminution be ſudden, it will be attended with a conſiderable ſhare of inteſtine motion, by which the particles muſt be irregularly moved, and will eventually come together with ſuch ſides or faces preſented to each other, as might not have been preſented if the irregularity of motion

motion had not interfered. In ſuch caſes the particles will form a ſolid, poſſeſſing little or no ſymmetry in its figure. This is called confuſed cryſtallization.

On the other hand it may happen, that by gradual evaporation, or cooling, the diminution of the quantities of ſolvent, or of heat, may take place ſo ſlowly as to occaſion a degree of motion altogether inconſiderable among the parts of the fluid. In this caſe, the particles which are about to ſeparate will approach each other with extreme ſlowneſs, and no circumſtance will interfere to prevent their applying ſuch ſides or faces towards each other as are beſt adapted to the governing laws of attraction. As ſoon as the particles have arrived to a diſtance leſs than is ſufficient for their mutual attraction to overcome the power of the fluid which ſuſpends them, they will ruſh together, and form ſymmetrical bodies poſſeſſing figures originating in, and dependent on the properties or nature of the particles which form them, and the ſymmetry will be more perfect the leſs the cryſtallization is influenced by diſturbing cauſes. This is called regular cryſtallization, and the ſymmetrical bodies are called cryſtals.

As the agitation ariſing from the cauſes juſt mentioned is ſufficient to prevent the regular formation of cryſtals, ſo likewiſe it is found that mechanical agitation is ſtill more deſtructive of their regularity. Slow cryſtallization produces ſugar candy; a quicker cryſtallization affords loaf ſugar. When a balloon ſome years ago was inflated at Moorfields by inflammable air, extricated by the action of vitriolic acid upon zinc, the white vitriol of commerce was afforded in beautiful tranſparent cryſtals, which the ſhops refuſed to purchaſe; but when by ſubſequent ſolution and mechanical agitation, a white maſs of confuſed cryſtals was obtained, the ſhop-keepers recognized the *white copperas* they had been uſed to deal in. The preſence or abſence of external impulſe is of ſo much conſequence in cryſtallization, that it may be doubted whether the action of light, which conſiderably impedes the formation of regular cryſtals, may not be attributed to this cauſe.

The permanent texture of bodies, their fracture, and other like circumſtances, appear to depend upon the ſtate of cryſtallization at the time of aſſuming the ſolid form. In metals, for example, the cryſtals are ſmaller and more confuſed the haſtier the cooling. Thus ſteel ſuddenly cooled breaks with a granular fracture, poſſeſſes a diminiſhed ſpecific gravity, and is very hard, whereas the ſame ſteel, more ſlowly cooled, will be denſer, ſofter, difficult to be broken aſunder, and when broken exhibits a very different internal texture. The cryſtals of other metals may be obtained by fuſing them in a crucible with a hole in its bottom cloſed by a ſtopper, which is to be drawn out after the veſſel has been removed from the fire, and the ſurface of the metal has begun to congeal. The ſame effect may be obſerved if the metal be poured into a plate or diſh, a little inclined, which is to be ſuddenly inclined in the oppoſite direction, as ſoon as the metal begins to congeal round its edges. In the firſt method, the fluid part of the metal runs out of the hole, leaving a kind of cup lined with cryſtals: in the latter way the ſuperior part, which is fluid, runs off, and leaves a plate of metal ſtudded over with cryſtals.

There is ſcarcely any experiment in chemiſtry which does not afford ſome appearance of a curious nature, referable to cryſtallization.

When bodies diſſolved in any fluid are ſeparated by cryſtallization, they are always found to retain a part of the fluid. The water thus retained by ſaline

cryſtals is called the water of cryſtallization. This water appears to be eſſential to the tranſparent cryſtalline form of ſalts, and is no doubt retained by virtue of their attraction for that fluid. From ſome experiments, in which a much greater degree of cooling was produced by the ſolution of cryſtallized ſoda than of ſuch as had loſt its water of cryſtallization, it may be inferred that this water exiſts in cryſtals in the congealed or ſolid ſtate, and perhaps much denſer than mere ice. Moſt ſalts may be deprived of their water of cryſtallization by mere heat. Some loſe it in the common temperature of the atmoſphere, and fall into a pulverulent maſs, called an efflorescence. Other ſalts attract water ſo ſtrongly that they draw it from the atmoſphere, and gradually become fluid, a phenomenon diſtinguiſhed by the name of deliqueſcence. Mr. Baumé affirms that the water of cryſtallization in all neutral ſalts with baſes of fixed alkali is pure, and they are not capable of taking up a redundancy of either principle in their cryſtals. This however may be doubted.

The cryſtallization of ſalts is uſually effected by evaporating part of the water; but it may likewiſe be made to take place by abſtraction of the water in the way of chemical affinity. Thus if ſtrong ardent ſpirit be added to an equal volume of a ſtrong ſolution of nitre, the ſpirit combines with the water, and almoſt the whole of the nitre ſeparates in an inſtant in the cryſtalline form. There is no doubt but appearances of this kind of ſeparation have miſled chemiſts on various occaſions.

The operation of cryſtallizing, or cryſtallization, is of great utility in the purifying of various ſaline ſubſtances. Moſt ſalts are ſuſpended in water in greater quantities at more elevated temperatures, and ſeparate more or leſs by cooling. In this property, and likewiſe in the quantity of ſalt capable of being ſuſpended in a given quantity of water, they differ greatly amongſt each other. It is therefore practicable in general to ſeparate ſalts from each other, by due management of the temperature and evaporation. For example, if a ſolution of nitre and common ſalt be evaporated over the fire, and a ſmall quantity be now and then taken out for trial, it will be found, at a certain period of the concentration, that a conſiderable portion of ſalt will ſeparate by cooling, and that this ſalt is for the moſt part pure nitre. When this is ſeen, the whole fluid may be cooled to ſeparate part of the nitre, after which, evaporation may be proceeded upon as before. This manipulation depends upon the different properties of the two ſalts with regard to their ſolubility and cryſtallization in like circumſtances. For nitre is conſiderably more ſoluble in hot than in cold water, while common ſalt is ſcarcely more ſoluble in the one caſe than in the other. The common ſalt conſequently ſeparates in cryſtals as the evaporation of the heated fluid goes on, and is taken out with a ladle from time to time, whereas the nitre is ſeparated by ſucceſſive coolings at proper periods.

Thoſe chemiſts who conſider heat as a peculiar ſubſtance and not a modification of matter, are in general inclined to reckon the fluid ſtate a ſolution in this matter; and the cryſtallization of bodies merely fuſed, is by them accounted for by the abſtraction of this ſuppoſed ſolvent.

It was natural for the earlier mineralogiſts and chemiſts to diſtinguiſh bodies by their ſymmetrical figures. Subſequent experience has however ſhewn that the cryſtallization of bodies is variable, by ſo many and ſuch minute circumſtances, that a conſiderable dependance on this ſingle attribute muſt neceſſarily be productive of error. Modern chemiſts, as the methods of analyſis became more

perfect, ſeem to have adopted a prejudice of the contrary nature, by almoſt totally rejecting the external figures of bodies as indications of their component parts. Romé de Liſle in his Cryſtallographie, Bergman in one of his Eſſays, and the abbé Haüy, have treated expreſsly and ſcientifically upon the formation of thoſe geometrical figures which conſtitute cryſtals; but the ſubject is very far from being enough ſimplified to admit of any ready application. The miner, the mineralogiſt, and the chemiſt will perceive a number of circumſtances in natural and artificial bodies relative to their configuration, grouping, colour, fracture, ſpecific gravity, &c. by means of which he may form very probable conjectures as to their contents, and the experiments requiſite to be inſtituted upon them: but in the preſent ſtate of ſcience, there is no method which can be ſubſtituted inſtead of actual inſpection, and the attentive conſideration of minerals and chemical products whoſe contents are previouſly known.

CULM. A term excluſively applied by dealers in pit-coal, to denote ſuch coal as does not cake, or adhere together, when heated. Small pieces of coal of this kind are of much leſs value than larger pieces; and on this account the duties on culm are leſs than upon coal. *See* COAL.

CUPEL. A ſhallow earthen veſſel ſomewhat reſembling a cup, from which it derives its name. It is made of phoſphorated lime, or the reſidue of burned bones rammed into a mold, which gives it its figure. This veſſel is uſed in aſſays wherein the precious metals are fuſed with lead, which becomes converted into glaſs, and carries the impure alloy with it. *See* ASSAY.

CUPELLATION. The refining of gold by ſcorification with lead upon the cupel is called cupellation.

CURD. The coagulum which ſeparates from milk upon the addition of acid or other ſubſtances. *See* MILK, *alſo* CHEESE.

D.

DAM DAM

DAMPS. The permanently elaſtic fluids which are extricated in mines, and are deſtructive to animal life, are called damps by the miners. The chief diſtinctions made by the miners, are choke-damp, which extinguiſhes their candles, hovers about the bottom of the mine, and conſiſts for the moſt part of aërial acid, or fixed air; and fire-damp, which occupies the ſuperior ſpaces, and does great miſchief by exploding whenever it comes in contact with their lights. The hiſtory of the effects of theſe fluids is very curious, and has been given much in detail by various writers. But the general properties of elaſtic fluids having of late years been much elucidated by the experiments of Dr. Prieſtley and others, it is at preſent found as eaſy to account, in a general way, for the wonderful effects of theſe fluids, as for any other appearances that take place in chemiſtry.

DAZE,

DAZE, or GLIMMER. A mine term applied to micaceous ſubſtances.

DECANTATION. The action of pouring off the clearer part of a fluid by gently inclining the veſſel after the groſſer parts have been ſuffered to ſubſide. Some chemiſts avoid the uſe of the filter altogether, and ſeparate ſolids from fluids by decantation. But there are ſituations in which either method may be preferable to the other.

DECOCTION. The operation of boiling. This term is likewiſe uſed to denote the fluid itſelf which has been made to take up certain ſoluble principles by boiling. Thus we ſay a decoction of the bark, or other parts of vegetables, of fleſh, &c.

Decoction is chiefly applied to organiſed ſubſtances, and is rather a culinary or pharmaceutical than a chemical operation. It ſerves to ſoften and conſiderably alter the parts of vegetables and animals; but its effects in general are too groſs and complicated to afford ſatisfactory theoretical reſults. In this proceſs the volatile parts, if any be preſent, fly away and are loſt; and it is attended with other inconveniences, which the chemical practitioner will very readily perceive.

DECOMPOSITION. This word was formerly uſed in a ſenſe almoſt oppoſite to that which univerſally prevails at preſent. Newton, Boyle and other earlier Engliſh writers, as the annotator on Macquer's Chemical Dictionary obſerves, uſed it to denote the compoſition or junction of two or more bodies which were previouſly compounded of other parts. But it is now underſtood to imply the ſeparation of the component parts or principles of bodies from each other.

It is diſtinguiſhable from diviſion, becauſe this laſt may conſiſt in the ſeparation of parts of the ſame nature as the body itſelf, which decompoſition does not. Thus common ſalt may be divided by pulverizing or otherwiſe, into parts of extreme minuteneſs, which ſtill continue to be common ſalt: but it cannot be ſaid to be decompoſed, until its alkali and acid are ſeparated from each other.

The decompoſition of bodies forms a very large part of chemical ſcience. It ſeems probable from the operations we are acquainted with, that it ſeldom takes place but in conſequence of ſome combination or compoſition having been effected. It would be difficult to point out an inſtance of the ſeparation of any of the principles of bodies which has been effected, unleſs in conſequence of ſome combination. The only exceptions ſeem to conſiſt in thoſe ſeparations which are made by mere heat; and theſe cannot be admitted as exceptions if we attend to the means by which the temperature was originally raiſed, or if we admit heat to be a peculiar ſubſtance.

DECREPITATION. The ſmall and ſucceſſive exploſions afforded in many chemical operations are diſtinguiſhed by this name. They are either produced by heating metallic ſubſtances with nitre, which take fire and explode, or elſe by ſuddenly heating cryſtallized bodies. Thus common ſalt which has been deprived of its water of cryſtallization by heat is called decrepitated. *See* SALT.

DELFT WARE. A kind of pottery made at Delft in Holland, which formerly ſupplied all Europe, until it was ſupplanted by a yellow pottery made in France, which has ſince given place to the queen's ware, and various kinds of china fabricated in Great Britain.

Pottery may be diſtinguiſhed into two kinds; namely, that which has a tranſparent varniſh or glaze, and that which has an opake glaze. The queen's ware, the ſtone ware, and various kinds of china are of the former ſort. The Delft ware and other kinds of china ware are of the latter kind. In every kind of

pottery it is an object of great importance that the expanſions and contractions of the glaze and the body ſhould be nearly the ſame at like temperatures: but this deſirable property is ſeldom found in veſſels covered with an opake glaze or enamel.

As the Delft pottery has fallen into diſuſe, it ſeems of leſs conſequence to enquire into its compoſition, more eſpecially as this diſuſe has been occaſioned by the production of better potteries. The following obſervations are taken * from a Memoir by Mr. Boſc d'Antic, in the 6th volume of the Mem. des Savans Etrangers.

Pure clay is not a fit material, when uſed alone, for the making of Delft ware. Different kinds of earths mixed together are found to ſucceed better. Pieces of ware made of clay alone would require too much time to dry; they would crack and would loſe their form, unleſs they were made exceedingly thick. An addition of marle is found to leſſen the contraction of the clay, renders it leſs compact, allows the water to eſcape in the drying of the ware without alteration of form, and affords a better ground for the enamel, which appears more gloſſy and white than when laid on clay alone.

The kinds of clay which are chiefly uſed in the compoſition of Delft ware, are the blue and green. But a mixture of blue clay and marle would not be ſufficiently ſolid, and would be apt to ſcale, unleſs it were expoſed to a fire more intenſe than what is commonly uſed for the burning of Delft ware. To give a greater ſolidity ſome red clay is added, which, on account of its ferruginous matter, poſſeſſes the requiſite binding quality. The proportions of theſe ingredients vary in different works, according to the different qualities of the earths employed. Three parts of blue clay, two parts of red clay, and five parts of marle, form the compoſition uſed in ſeveral manufactories. M. D'Antic thinks that the beſt Delft might be made of equal parts of pure clay and pure calcareous earth; but this compoſition would require that the fire ſhould be continued twice as long as it generally is.

The preparation of the white enamel with which this ware is glazed, is another eſſential part in which many artiſts fail. M. D'Antic recommends for this purpoſe a mixture of an hundred pounds of calx of lead, with about a ſeventh part of that quantity of calx of tin for common Delft, or a fourth part of calx of tin for the fineſt Delft; an hundred, or an hundred and ten pounds of fine ſand; and about twenty or thirty pounds of ſea-ſalt, or ſalt of glaſs.

DELIQUESCENCE. The ſpontaneous aſſumption of the fluid ſtate by certain ſaline ſubſtances, when left expoſed to the air, in conſequence of the water they attract from thence.

We know of no criterions to determine, à priori, whether any combination ſhall be conſiſtent, effloreſcent or deliqueſcent in the air. It appears that whenever any ſalt attracts moiſture more ſtrongly than the air is diſpoſed to retain it, it is deliqueſcent; and, on the contrary, if the air be more attractive of moiſture, it will cauſe the ſalt to effloreſce. Salts, which are not commonly deliqueſcent, will be liquefied in a very humid air, and other ſalts ſtrongly attractive of humidity may be dried in proper ſituations.

Generally ſpeaking, the ſimpler ſubſtances are more deliqueſcent than ſuch as are compounded. So the acids and pure alkalis are all ſtrongly attractive of

* In a note to the Engliſh tranſlation of Macquer's Dictionary.

water; moſt of the former being diſpoſed to riſe in diſtillation, long before they are deprived of the laſt portions of water, and conſequently they are conſtantly in the fluid ſtate, unleſs when congealed by cold.

DELIQUIUM. Deliqueſcent ſalts are by ſome writers ſaid to fall into a deliquium.

DEMI-METAL. A word ſometimes uſed for ſemi-metal, which ſee.

DEPHLEGMATION. Any method by which bodies are deprived of water. The term is nearly ſynonimous with concentration. It is effected either by evaporation or congelation, and is chiefly uſed in ſpeaking of very aqueous fluids, whereas the word concentration is uſually applied to the extreme dephlegmation of acids.

DEPHLOGISTICATED. Deprived of phlogiſton, or the inflammable principle. As the exiſtence of this principle is an object of controverſy, it would be deſirable if all terms referring to it were avoided. The pale nitrous acid is called dephlogiſticated nitrous acid: eminently reſpirable air or vital air is called dephlogiſticated air; the more perfect calces of metals are ſaid to be dephlogiſticated, &c. and in all theſe and other caſes it is eaſy to expreſs the mere facts without uſing this or any other term dependant upon theory.

DEPHLOGISTICATED AIR. *See* AIR, VITAL.

DERBYSHIRE SPAR. A combination of calcareous earth with a peculiar acid called the ACID OF FLUOR, which ſee.

Fluor ſpar is ſcarcely harder than the common calcareous ſpar. It affords no efferveſcence with acids, though totally ſoluble in nitrous or marine acid. In an heat below ignition it affords a phoſphoreſcent light, as may be tried by placing a ſmall piece upon an heated poker. Borax eaſily diſſolves it before the blow-pipe, as does alſo the microcoſmic ſalt without ebullition.

This ſpar is uſed as a flux at the mines, whence it has its name. Very elegant ornaments are made of it, which are ſold in London at prices which may be termed extravagant, unleſs there be difficulties in the cutting and poliſhing of which I am not aware, and ſuppoſe there is no reaſon to imagine.

When the acid of ſpar ſhall be applied to more extenſive uſes than at preſent, this ſubſtance will become of value on that account.

DESTRUCTIVE DISTILLATION. When organiſed ſubſtances or their products are expoſed to diſtillation until the whole has ſuffered all that the furnace can effect, the proceſs is called deſtructive diſtillation. As this method decompoſes bodies ſo as to ſeparate their component parts from each other into a ſtate of conſiderable ſimplicity: and as the original principles of organiſed bodies ſeem to be few, the products of ſubſtances of the vegetable kingdom, though much differing from each other at firſt, are found to poſſeſs characters ſo ſimilar as to render the method of no great uſe, unleſs in conjunction with other proceſſes. The ſame may be obſerved of the deſtructive diſtillation of animal ſubſtances.

DETONATION. A ſudden combuſtion and exploſion. The detonations obſerved in chemical experiments are moſtly cauſed by the deſtruction of the acid of nitre in contact with ſome combuſtible ſubſtance. This acid takes fire ſpontaneouſly when applied to charcoal or to eſſential oils (*ſee* ACID, NITROUS): but the ſudden exploſion called detonation requires that the acid ſhould be in a ſtate nearly or completely dry, and the inflammable ſubſtance of conſiderable fixity.

Various

Various theories of detonation exhibiting conſiderable ingenuity have been maintained by the earlier chemiſts, in which the facts are accurately ſtated and plauſibly accounted for. The diſcoveries of the moderns were however wanting to elucidate this ſubject. Nitrous ſalts are decompoſable by mere heat, the acid being ſeparated into its component parts, phlogiſticated and vital air. It is this vital air which ſo ſtrongly and ſuddenly deſtroys combuſtible ſubſtances in the way of detonation. The detonation of common nitre and charcoal is one of the moſt common, and is ſeen in the effects of *gunpowder* (which ſee). In experiments of this kind it is remarkable, that the combuſtion is maintained by vital air, which is not in the elaſtic ſtate, but fixed in the nitre: whence it ſhould follow, that either the vital air or the combuſtible body, even in the fixed ſtate, have a great capacity for heat, of which they contain a large quantity, on the hypotheſis of heat being matter. Or if heat be a mere commotion, it will follow that, though the quantity of agitation produced by the ſudden coalition of particles, in the act of converting an elaſtic fluid into a denſe body, be ſuch as to produce a great effect in increaſing the temperature; yet the quantity is ſtill conſiderable enough, when vital air and combuſtible matter unite even in their denſe ſtate, to cauſe the moſt intenſe degree of ignition. *See* CLYSSUS.

The dephlogiſticated or aerated marine acid, being much more ready to part with its vital air than the nitrous acid, is found to afford a much more ſudden and ſtronger detonation. A new kind of gunpowder has accordingly been made out of the ſalt produced by the combination of this aerated acid and the vegetable alkali, for which recourſe may be had to the article *gunpowder*.

The moſt remarkable detonations in chemiſtry are afforded by *gunpowder*, *fulminating powder*, fulminating *gold*, fulminating *ſilver*, certain calces of *mercury*, and the *gunpowder* of dephlogiſticated marine acid, which ſee.

DEW. Formerly this name was given to the phlegm that roſe firſt in the diſtillation of ſeveral ſubſtances: thus the dew of vitriol, the dew of honey, were the watery liquors, which riſe firſt when theſe ſubſtances are diſtilled.

DIAMOND. The diamond is a mineral which, on ſeveral accounts, appears worthy to compoſe an order by itſelf. It is found in a ſandy earth in the hither peninſula of India, in the iſland of Borneo, and in the Brazils. The form of the diamond, when perfect, is that of an eight-ſided priſm. There are alſo cubical diamonds, which are ſuſpected to be of a different nature from the others. Diamonds are of a lamellated texture, and may be eaſily ſplit by a blow in a proper direction. The conſent of mankind has fixed an immenſe value upon this ſtone. The inimitable qualities to which this preference is attached, are its hardneſs, which is ſuch that it eaſily cuts all other ſubſtances, and takes a moſt exquiſite and laſting poliſh; and its very great refracting power, which is ſo conſiderable as to occaſion all the light to be reflected, which falls on any of its interior ſurfaces, at a greater angle of incidence than 24¼ degrees. Hence its luſtre, when cut into the form of a regular ſolid, is very great. This may be eaſily underſtood, when it is conſidered that an artificial gem does not reflect the light from its hinder ſurface, until that ſurface is inclined in an angle of 41 degrees. The diamond therefore will not only throw back all the light which an artificial gem would reflect, but likewiſe one half as much more; which, falling between the angles of 41 degrees and 24¼, would have been ſuffered to paſs through by the falſe gem. It is not ſurpriſing, therefore, that the effect of the diamond

ſhould be ſo much greater; more eſpecially when we attend to its extreme tranſparency, and the accuracy of its poliſh.

No ſolvent but the vitriolic acid has any effect on this gem; in which if diamond powder be triturated, and evaporation carried on nearly to dryneſs, the acid grows black, and depoſits pellicles that burn, and are entirely conſumed. In a heat ſomewhat greater than is required to melt ſilver, the diamond is entirely volatilized, and conſumed with a ſlight flame; diminiſhing common air, and leaving a ſoot behind.

Diamonds are of all colours: the clear tranſparent ſtones are the moſt eſteemed; and, next to them, thoſe of a deeper tinge. Whether theſe coloured ſtones be really of the ſame nature as the clear diamond, has not been aſcertained. The lapidaries reckon them to be diamonds from their hardneſs and luſtre.

The value of diamonds is reckoned by weight, at ſo much the carat. The carat uſed in this valuation is divided into four parts, called grains; but leſs than troy grains by one fifth; for one hundred and fifty carats are equal to the troy ounce of four hundred and eighty grains. Rough diamonds, without any flaw or blemiſh, are valued at two pounds ſterling the ſingle carat; and the expence of cutting amounts to $3\frac{3}{4}$ pounds the carat. The value is greatly diminiſhed if the diamond be imperfect, or of a bad figure; and it increaſes rapidly with the ſize. To find the worth of a rough diamond, its weight in carats muſt be ſquared, and multiplied by two, and the product will be pounds ſterling. A cut or finiſhed diamond is worth four times as much as one that is ſtill rough. Thoſe of the greateſt brilliancy are ſometimes valued at a higher rate; but this value has never been applied to ſtones of exceſſive magnitude. It does not appear that any ſum exceeding one hundred and fifty thouſand pounds has been given for a diamond. See Magellan's improved edition of Cronſtedt's Mineralogy, for a conſiderable maſs of entertaining information on this ſubject.

DIAPHORETIC ANTIMONY. This is a white calx of antimony, made by calcining antimony with thrice its weight of nitre. *See* ANTIMONY.

DIGESTION. The ſlow action of a ſolvent upon any ſubſtance for a length of time, is called digeſtion by chemiſts. In this operation the action of the ſolvent is frequently aſſiſted by heat, in ſome inſtances ſtronger than in others, but ſeldom equal to that of boiling water. Chemical writers frequently mention a digeſting heat. No definite application is made of theſe terms, but they uſually ſignify a degree of heat exceeding that of living animals, and leſs than that of boiling water, ſuch as may be produced by placing a veſſel in hot aſhes. It may therefore be taken to be ſomewhere about 150 degrees.

DIGESTIVE SALT. One of the names which have been given to the neutral combination of marine acid and vegetable alkali.

DIGESTOR. The digeſtor is an inſtrument invented by Mr. Papin about the beginning of the preſent century, and uſually called Papin's digeſtor. It is a ſtrong veſſel of copper or iron, with a cover adapted to ſcrew on with pieces of felt or paper interpoſed. In ſome veſſels of this kind the cover is made of an elliptical form, and is inſerted through an opening of the ſame figure, which it completely cloſes by application of its upper ſurface to the internal ſurface of the veſſel. A valve with a ſmall aperture is made in the cover, the ſtopper of which valve may be more or leſs loaded either by actual weights, or by preſſure from an apparatus on the ſteel-yard principle.

The

The purpoſe of this veſſel is to prevent the loſs of heat by evaporation. The ſolvent power of water when heated in this veſſel is greatly increaſed, chiefly no doubt on account of its increaſed temperature, and likewiſe in all probability on account of the preſſure exerted by the re-action of the elaſtic water or ſteam which is upon the point of being generated.

I do not hear of many experiments made by this engine. The inventor propoſed it as a culinary utenſil, by which the griſly and bony parts of animals might be combined with water in the form of a jelly, as is in fact the caſe. But whether a food ſo loaded with the phoſphoric ſalt of lime would be wholeſome may perhaps admit of ſerious doubts.

Bergman thought that the digeſtor might exhibit a conſiderable ſolvent power of water upon the pure earths, and he conſidered the depoſition of ſiliceous earth from the hot water of the ſtupendous fountain of Geyſer in Iceland, mentioned by Vontroil, as a proof of ſuch a ſolution.

DISTILLATION. The ſeparation of a volatile fluid from other ſubſtances which are leſs volatile, by applying a due degree of heat to the mixture, and afterwards condenſing the vapours in another part of the apparatus by cooling. The older chemical writers diſtinguiſhed three kinds of diſtillation, per aſcenſum, per deſcenſum, and per latus.

The diſtillation per aſcenſum is performed with an alembic: here the elaſtic vapours riſe perpendicularly, and are condenſed in the head of the veſſel, from which they run into the receiver through the beak. Large ſtills are conſtructed on this principle. The chief advantage it ſeems to poſſeſs conſiſts in the facility with which the reſidues of the diſtillation may be come at; and in thoſe few inſtances wherein conſiderable quantities of flowers or pulverulent matter riſe along with other vapours which are condenſed into the fluid form, it may perhaps afford ſome facility in ſeparating them.

The diſtillation formerly denominated per deſcenſum conſiſted in placing certain herbs or other ſubſtances in a ſhallow tray or cullender, which was applied like a cover to a tall cylindrical glaſs veſſel. Another cover was then laid over this cullender, which conſiſted of a pan containing lighted charcoal. The heat was therefore applied above the materials, and the volatile parts were forced to deſcend and became condenſed againſt the ſides of the veſſel. Philoſophical chemiſts at preſent conſider this method as entirely uſeleſs; but there are ſeveral inſtances of its convenient and advantageous application in large works, as in the diſtillation of zinc, of pit-coal, and other ſubſtances.

The diſtillation per latus is the ſimpleſt and moſt extenſively uſed: a retort and a receiver are the feweſt veſſels which can be uſed in this way; and where the heat is properly managed, every operation of the other methods may be performed in this way with great facility. It has accordingly happened that moſt of the improvements of diſtillation for philoſophical purpoſes have been made in this method. *See* APPARATUS.

The general rule for performing all diſtillations in the moſt ſafe, accurate, and perfect manner conſiſts in applying no more heat than is neceſſary to raiſe the volatile matter, and in keeping the receiving apparatus ſufficiently cool, either by ſurrounding it with wet cloths, immerſing it in water, occaſionally renewed or kept cold by putting ice or ſnow into it, &c.

DITTANY OF CRETE. Sixteen ounces of the leaves of this plant yield about half a dram of a ſtrong, aromatic, eſſential oil, which coagulates by cold, reſembling

reſembling camphor. From an ounce of this plant Neumann obtained with water two drams and a ſcruple of extract; and from the ſame quantity, with ſpirit of wine, he obtained a dram and a half of reſinous extract. He obſerves that the green colour of the leaves reſides in the reſin, and is extractible by ſpirit, eſpecially after water had previouſly extracted the gummy part, ſome of which being alſo ſoluble by ſpirit along with the reſin, alters the colour of the ſpirituous tincture.

DIVISION. Some writers uſe this word as a term to denote every mechanical ſeparation of the parts of bodies. According to this notion, clipping, pounding, trituration, levigation and the like, are methods of diviſion.

DOCIMASTIC ART. This name is given to the art of aſſaying, or determining by experiments in the ſmall way, the quantities and nature of the component parts of bodies intended to be uſed in commerce. *See* ASSAY, BLOW-PIPE, ANALYSIS, and the ſeveral metals.

DOME. An hemiſpherical covering of forged iron, with a tube or chimney proceeding from its upper part. The cavity between the dome and the fuel, and likewiſe the internal ſpace in the chimney, being filled with air much rarefied by heat produce a ſtrong draft, and greatly increaſe the intenſity of the fire. It has alſo been ſuppoſed to reflect the heat or flame upon the veſſels, and on that account a furnace with a cover of this form is called a reverberatory furnace.

DORONICUM. From two ounces of the dry root were obtained by water fourteen drams of extract; and from the ſame quantity, with ſpirit, four drams and a half. This root is ſuppoſed by ſome to be poiſonous, eſpecially when freſh.—Neumann.

DRAGON'S BLOOD is a red-coloured, inodorous, and inſipid reſin, inſoluble in water, ſoluble in ſpirit of wine and in oils, to both which liquors it communicates a red colour. By fire it is fuſible, inflammable, and it emits an acid vapour, like that of benzoin. A ſolution of dragon's blood in ſpirit of wine is uſed for ſtaining marble, to which it gives a red tinge, which penetrates more or leſs deeply according to the heat of the marble during the application. But as it ſpreads at the ſame time that it ſinks deep, for fine deſigns the marble ſhould be cold. Mr. Du Fay ſays, that, by adding pitch to this ſolution, the colour may be rendered deeper.

DRAKE *or* DRUSE-HOL. A Swediſh denomination uſed to expreſs a cluſter of cryſtals which line a cavity in any mineral.

DRYING-OIL. Fat oils require a very long time to become conſiſtent by expoſure to the atmoſphere; but painters render them more diſpoſed to dry, by boiling them with calces of lead. Linſeed oil holding calx of lead in ſolution, which it takes up by boiling with litharge, is called drying oil from this property.

DUCTILITY. That property or texture of bodies which renders it practicable to draw them out in length, while their thickneſs is diminiſhed without any actual fracture of their parts. This term is almoſt excluſively applied to metals, and implies that they are capable of being made into wire, by drawing a portion of the metal through an hole in a plate of ſteel or other proper compoſition. The ductility of a metal depends therefore on two circumſtances, namely, its malleability or property of extending by preſſure, and its tenacity or power of reſiſting an actual ſeparation of its parts. If the metal be not malleable

enough, it will reſiſt the action of the wire-drawer's plate, and not change its figure to a ſufficiently ſmall diameter to come through: if, on the other hand, it be very malleable, but at the ſame time deficient in tenacity, the part which has been put through the hole may not be ſtrong enough to bear, without breaking, that pull which is neceſſary to form the wire.

Gold, ſilver, platina, copper, and iron have tenacity and malleability enough to afford very fine wire. Lead and tin have not tenacity enough to be wrought in this way to any advantage, though the hammer and the laminating rollers are capable of extending them to extreme thinneſs. Zinc laminates very well, but ſcarcely ſupports the ſudden action of the hammer without breaking, and is altogether unfit to be drawn into wire.

Moſt authors confound the words malleability, laminability, and ductility together, and uſe them in a looſe indiſcriminate way; but they are very different. Malleability is the property of a body which enlarges one or two of its three dimenſions, by a blow or preſſure very ſuddenly applied. Laminability belongs to bodies extenſible in dimenſion by a gradually applied preſſure. And ductility is properly to be attributed to ſuch bodies as can be rendered longer and thinner by drawing them through an hole of leſs area than the tranſverſe ſection of the body ſo drawn.

DUCKSTEIN. The duckſtein of the Germans is a white calcareous ſtone, formed by the depoſition of chalk from water, in which it is diffuſed. It is generally formed on branches or roots of trees, and ſtones of different kinds, and differs from the ſtalactites in its mode of formation, this laſt being depoſited by water in the act of evaporation as it tranſudes through the roofs of caverns.

DULCIFICATION. A medical proceſs conſiſting in combining the mineral acids with ardent ſpirit by digeſtion, or more frequently by diſtillation. The proceſſes for this purpoſe are not in general very ſcientific. When ether is made, the firſt produce is very pure ardent ſpirit, little altered, or ſlightly combined with ſome acid; next the ether, then phlogiſticated or partly decompoſed acid, with ſome vinegar, according to the management of the operation. The dulcified acids of the diſpenſatories conſiſt of an admixture of theſe products, which in all probability is ſeldom the ſame in different laboratories, where the degrees of heat, the time of charging the receiver, and other eſſential circumſtances, are liable to be varied.

DYING. The art of dying is conſidered as of great importance to ſociety, according to its preſent habits and uſages. It conſiſts in fixing upon cloths of various kinds any colour which may be required, in ſuch a manner as that they ſhall not be eaſily altered by thoſe agents to which the cloth will moſt probably be expoſed during its courſe of wear.

As there can be no probable cauſe by which any colouring matter can adhere to any cloth, except an attraction ſubſiſting between the two ſubſtances, it muſt follow that there will be few tingeing matters capable of indelibly or ſtrongly attaching themſelves by ſimple application. For ſuch an attachment would miply that the elective attraction by which it was effected was ſtronger than all or moſt others; a circumſtance in the order of events not likely to happen often. On this account it is that moſt of the dying proceſſes appear to conſiſt in applying ſome ſubſtance or principle to the cloth, which forms a colouring matter, nearly inſoluble by combining with ſome other principle applied to it in its ſtate of adheſion to the cloth.

Dying is therefore a chemical art; and if the operations were no more complicated than is here expreſſed, it would be eaſy not only to acquire a perfect theory of its proceſſes, but likewiſe to bring many of them to perfection, which at preſent conſtitute its greateſt reproach. But the effects and combinations produced in this way being not only to all appearance dependant on compound actions of chemical affinity, but likewiſe in general produced by means diſcovered by mere and almoſt caſual trial, it is found that no ſmall degree of ſagacity and aſſiduous reſearch are neceſſary to determine the uſes and advantages of the ſeveral ingredients. In addition to theſe impediments, the theory of dying has been greatly impeded in its progreſs, by the little intereſt men of ſcience have found in attempting to repeat its manipulations, and the jealouſy of manufacturers, who, with ſome juſtice, are inclined to eſtimate their property in their own gainful diſcoveries, as a poſſeſſion which they have a right to monopolize by keeping them ſecret. It has accordingly happened from theſe cauſes, that dying has been merely a practical art, till very lately, that it has been cultivated by a few eminent chemiſts.

The earlier theories of dying, like the commencements of the other branches of natural philoſophy, have been deduced in objects apparently too remote for our preſent means of inveſtigation, namely, the configuration of the particles of bodies. Newton, from obſervations on the colours exhibited by light reflected from, or tranſmitted through, thin tranſparent bodies, as exhibited in experiments too few and imperfect to have afforded ſatisfactory concluſions in the hands of a philoſopher of leſs ſagacity, formed a general inference, that the colours of all bodies are governed by the magnitude of their particles. He likewiſe brought their denſities into conſideration, as a modifying circumſtance, but this only in a conjectural way, and he altogether overlooked that property which on another occaſion he had noticed as increaſing their refracting power, namely their combuſtibility. M. Delaval, in his Treatiſe on Light and Colours, and a ſubſequent paper in the Mancheſter Memoirs, has diſplayed this doctrine very much at large, with many valuable improvements and diſcoveries. It is evident however that much remains to be done before any clear and practical application of this theory can take place. If we ſuppoſe that a due magnitude and refractive power be all that is neceſſary for the particles of bodies to exhibit a determinate colour in white light, which indeed ſeems to be nearly proved, we ſhall find no data among our preſent acquiſitions ſufficient to afford any determination of theſe requiſites. To produce a green colour there will be no conſtant thickneſs or magnitude of particles required; for this will vary with the reflective power. We know that the reflective and refractive powers are the ſame, and are not governed by the mere denſity, but are greateſt in combuſtible bodies. And when, in addition to theſe difficulties with groſſer bodies, we obſerve that there is no poſſibility of determining either the magnitude, figure, denſity, or other obvious properties of indiſcernible particles, we may juſtly conclude that it will be a long time before we ſhall be able to apply the Newtonian theory to the art of dying.

The theory of the celebrated Hellot, ſuppoſed that the pores of bodies are opened by the heat uſed in dying, that the colouring matter was depoſited in theſe interſtices, and there firmly held by the ſubſequent contraction of cooling, aſſiſted by a kind of varniſh or covering depoſited by the ſalts made uſe of. This theory has not met with much ſucceſs, though, like other hypothetical

ſpeculations on obſcure objects, it may not be difficult to apply it to moſt of the known facts. It is moreover contradicted not only by the circumſtance that the ſtuff does not in all inſtances take the colour of the dyer's bath, but ſome other colour, and that it ſometimes happens that the bath, inſtead of ſharing its colour with the ſtuff, as it ought to do, is rendered as clear as water by an entire privation of all its tinging matter: both which circumſtances evidently prove that a chemical combination takes place in conſequence of an attraction exerted between the ſtuff and the colouring matter.

The attention of philoſophers is not therefore at preſent much directed towards the mechaniſm of the particles of bodies uſed in dying, but to the elective attractions exerciſed between them, and the nature of the compounds they form. In this enquiry they have naturally endeavoured to extend their reſearches by endeavouring to generalize particular facts. Some have ſuppoſed the various colours of bodies to be in a very great meaſure owing to the preſence of iron; a body the moſt univerſally diffuſed, and ſuſceptible of a great variety of ſhades of colour, according to the degree of calcination it may have undergone. It does not however appear that this metal, though ſo widely diffuſed, is found in ſufficient quantity to be admitted as the efficient cauſe of the tinges induced upon bodies. But the more modern chemiſts have with no ſmall degree of probability applied the doctrines of combuſtion and revivification, or the combination and diſengagement of vital air to the fixation and diſcharging of colours.

The moſt remarkable general fact in the art of dying conſiſts in the different degrees of facility with which animal and vegetable ſubſtances attract and retain colouring matter, or rather the degree of facility with which the dyer finds he can tinge them with any intended colour. The chief materials of ſtuffs to be dyed are wool, ſilk, cotton and linen, of which the former are more eaſily dyed than the latter. This has been uſually attributed to their greater attraction to the tinging matter; though it does not appear to be true in all caſes, becauſe the ſtuffs more difficult to be dyed will abſorb a greater quantity of that matter, before they acquire the requiſite intenſity of colour obtainable in the former by a leſs proportion of the ſame drug. In every attempt to deduce the cauſes of theſe different effects, it is proper to enquire into the properties of theſe bodies by experiment.

Wool, ſilk, cotton, and linen, though in various reſpects ſimilar to each other, are nevertheleſs found to differ exceedingly in others. In the method of* deſtructive diſtillation, wool yields much impure volatile alkali, a portion of empyreumatic oil, leaving about one fifth of incombuſtible fixed reſidue. Silk affords leſs volatile alkali and oil, and more reſidue. Cotton affords no volatile alkali and little oil, but ſome acid, leaving little coal which may for the moſt part be burned by calcination in the air. Here we obſerve a very conſiderable difference in the habitudes and products of the ſeveral ſubſtances; but the ſcientific experiments of Berthollet ſhew it ſtill more evidently. He diſtilled nitrous acid from ſilk†, and obtained ſaccharine acid, with a greaſy matter, which, though it at firſt congealed on the ſurface of the liquor in the receiver, was afterwards diſſolved in it by means of heat, even though diluted with water with which it paſſed through the filter. Wool alſo afforded the ſame greaſy matter, and acid of ſugar; the laſt of which was more abundant in quantity than he obtained by the ſame

* Neumann. † Journal de Phyſ. xxix.

treatment from any other ſubſtance. But the oily part of vegetables was totally deſtroyed by ſimilar treatment, no greaſy matter being afforded; and on analyſing cotton, he obtained ſaccharine acid, but no other product, and the quantity was far inferior to that yielded by animal ſubſtances. It was remarkable that the cotton left no reſidue, but was entirely converted into elaſtic fluid and ſaccharine acid, which laſt is likewiſe eaſily convertible into the permanently elaſtic acid, called fixed air.

Mr. Henry, * in his remarks on theſe experiments, appears to think that the chief difference between the animal and vegetable ſubſtances conſiſts in the former containing a more abundant greaſy principle, ſoluble in a watery menſtruum, which the more ſparing portion of oil in the latter is not; and likewiſe in the animal ſubſtance containing alkali, or at leaſt one of its component parts: whereas the vegetable affords acid. On theſe circumſtances indeed the different modes of treatment evidently depend. So that it is remarkable that vegetable ſubſtances, whoſe oil is wholly deſtroyed by nitrous acid, and to whoſe texture the mineral acids are in general injurious, will bear ſteeping in ſolutions of cauſtic alkali of ſuch ſtrength as would prove totally deſtructive to wool.

Wool is naturally ſo much diſpoſed to combine with colouring matter that it requires but little preparation for the immediate proceſſes of dying; nothing more being required than to cleanſe it, by ſcouring from a fatty ſubſtance, called the yolk, which is contained in the fleece. For this purpoſe an alkaline liquor is neceſſary; but as alkalis injure the texture of the wool, a very weak ſolution muſt be uſed. For if more alkali were preſent than is ſufficient to convert the yolk into ſoap, it would attack the wool itſelf. Putrid urine is therefore generally uſed, as being cheap and containing a volatile alkali, which uniting with the greaſe, renders it ſoluble in water.

Silk when taken from the cone is covered with a kind of varniſh, which, becauſe it does not eaſily yield either to water or ardent ſpirit, is uſually ſaid to be ſoluble in neither. It is therefore uſual to boil the ſilk with an alkali, to diſengage this matter. Much care is neceſſary in this operation, becauſe the ſilk itſelf is eaſily corroded or diſcoloured. Fine ſoap is commonly uſed, but even this is ſaid to be detrimental; and the white China ſilk, which is ſuppoſed to be prepared without ſoap, has a luſtre ſuperior to that of Europe. It is however more than probable that the Chineſe have a different kind of ſilk-worm beſides that cultivated in Europe. A weak ſolution of mild mineral alkali has been uſed with ſucceſs by M. Rigaut, in clearing ſilk of its varniſh, and the Abbé Cullomb has performed the ſame thing by boiling ſilk for nine hours in water. Silk loſes about one fourth of its weight by being deprived of its varniſh.

The whiteneſs and ſoftneſs of ſilk is conſiderably improved by clearing it of its varniſh; but it receives a ſtill farther degree of brilliancy by expoſing to the fumes of ſulphur, ſublimed or ſet on fire in a cloſe ſtove or cloſet. What happens in this operation has not been well explained. Silk thus treated has a criſp feel, as if flowers of ſulphur were incloſed between its threads, which is probably the caſe. It ſeems as if a portion of the ſulphur entered into combination with the colouring principle of the ſilk, and formed a colourleſs or tranſparent compound: and accordingly it is found leſs capable, in general, of being eaſily dyed than the ſilk which has not been ſcoured and ſulphured.

* Mancheſter Memoirs III.

Cotton

Cotton and linen are cleared of a tinging matter, which Mr. Kirwan finds in the latter to be neither gummy nor reſinous, but rather reſembling lac. Alkalis act upon this matter, and diſſolve it after it has ſuffered a kind of combuſtion by expoſure to air and the ſun's light in the bleach ground. *See* BLEACHING.

The intention of the previous preparations ſeems to be of two kinds. The firſt to render the ſtuff or material to be dyed as clear as poſſible, in order that the aqueous fluid to be afterwards applied, may be imbibed and its contents adhere to the minute internal ſurfaces. The ſecond is, that the ſtuff may be rendered whiter and more capable of reflecting the light and conſequently enabling the colouring matter to exhibit more brilliant tints.

Some of the preparations however, though conſidered merely as preparative, do really conſtitute part of the dying proceſſes themſelves. In many inſtances a material is applied to the ſtuff to which it adheres, and when another ſuitable material is applied, the reſult is ſome colour deſired. Thus we might dye a piece of cotton black, by immerſing it in ink; but the colour would be neither good nor durable, becauſe the particles of precipitated matter formed of the calx of iron, and acid of galls, are already coagulated in maſſes too groſs either to enter the cotton, or to adhere to it with any conſiderable degree of ſtrength. But if the cotton be ſoaked in an infuſion of galls, then dried, and afterwards immerſed in a ſolution of vitriol (or other more proper ferruginous ſalt), the acid of galls being every where diffuſed through the body of the cotton, will receive the particles of calx of iron, at the very inſtant of their tranſition from the fluid or diſſolved to the precipitated or ſolid ſtate; by which means a perfect covering of the black inky matter will be applied in cloſe contact with the ſurface of the moſt minute fibres of the cotton. This dye will therefore not only be more intenſe, but likewiſe more adherent and durable.

The French dyers, and after them the Engliſh, have given the name of the mordant to thoſe ſubſtances which are previouſly applied to piece goods, in order that they may afterwards take a required tinge or dye.

It is evident that if the mordant be univerſally applied over the whole of a piece of goods, and this be afterwards immerſed in the dye, it will receive a tinge over all its ſurface; but if it be applied only in parts, the dye will ſtrike in thoſe parts only. The former proceſs conſtitutes the art of dying, properly ſo called; and the latter, the act of painting, ſtaining, or printing, woollens, cottons, or linens.

In the art of printing piece goods, the mordant is uſually mixed with gum ſeneca and applied by means of blocks or wooden engravings in relief, or from copper plates, and the colours are brought out by immerſion in veſſels filled with ſuitable compoſitions. Dyers call the latter fluid the bath. The art of printing affords many proceſſes in which the effect of mordants, both ſimple and compound, are exhibited. The following is taken from Berthollet.

The mordant employed for linens, intended to receive different ſhades of red, is prepared by diſſolving in eight pounds of hot water, three pounds of alum, and one pound of ſugar of lead, to which two ounces of potaſh and afterwards two ounces of powdered chalk, are added.

In this mixture the vitriolic acid combines with the lead of the ſugar of lead, and falls down becauſe unſoluble, while the argillaceous earth of the alum unites with the acetous acid diſengaged from the ſugar of lead. The mordant therefore conſiſts of an argillaceous acetous ſalt, and the ſmall quantities of alkali and chalk

chalk ſerve to neutrallize any diſengaged acid which might be contained in the liquid.

Several advantages are obtained by thus changing the acid of the alum. Firſt, the argillaceous earth is more eaſily diſengaged from the acetous acid, in the ſubſequent proceſſes, than it would have been from the vitriolic. Secondly, this weak acid does leſs harm when it comes to be diſengaged by depriving it of its earth. And thirdly, the acetous alum not being cryſtallizable like the vitriolic alum, does not ſeparate or curdle by drying on the face of the blocks, for printing, when it is mixed with gum or ſtarch.

When the deſign has been impreſſed by transferring the mordant from the face of the wooden blocks to the cloth, it is then put into a bath of madder, with proper attention that the whole ſhall be equally expoſed to this fluid. Here the piece becomes of a red colour, but deeper in thoſe places where the mordant was applied. For ſome of the argillaceous earth had before quitted the acetous acid, to combine with the cloth; and this ſerves as an intermedium to fix the colouring matter of the madder in the ſame manner as the acid of galls, in the former inſtance, fixed the particles of calx of iron. With the piece in this ſtate, the callico-printer has only therefore to avail himſelf of the difference between a fixed and a fugitive colour. He therefore boils the piece with bran, and ſpreads it on the graſs. The fecula of the bran takes up part of the colour, and the action of the ſun and air renders more of it combinable with the ſame ſubſtance. The operations of boiling with bran and expoſure in the field are alternately repeated till the ground becomes white and the deſign only remains. It ſeems evident that this diſcharge of the colour is performed nearly in the ſame way as bleaching, the bran being ſubſtituted inſtead of the alkali, becauſe this laſt would act upon the printed colour and partly diſcharge it.

In the foregoing inſtance the mordant was completely formed by the effect of the double elective attraction of the principles of the ſugar of lead and of the alum. In other caſes however the elective attraction of the ſtuff to be dyed has a more marked agency. A very common mordant for woollens is made by diſſolving alum and tartar together; neither of which is decompoſed, but may be recovered by cryſtallization upon evaporating the liquor. Wool is found to be capable of decompoſing a ſolution of alum, and combining with its earth: but it ſeems as if the preſence of diſengaged vitriolic acid ſerved to injure the wool, which is rendered harſh by this method of treatment, though cottons and linens are not, which have leſs attraction for the earth. Wool alſo decompoſes the alum, in a mixture of alum and tartar: but in this caſe there can be no diſengagement of vitriolic acid, but it is immediately neutralized by the alkali of the tartar.

Alum is an exceedingly uſeful agent in dying proceſſes, and M. Berthollet has ſatisfactorily proved, by a variety of experiments, that its earth has a ſtrong tendency to unite with animal matters, and that its attraction for vegetable ſubſtances is very weak, excepting to their colouring parts.

Metallic calces have ſo great an attraction for many colouring ſubſtances, that they quit the acids in which they were diſſolved, and are precipitated in combination with them. Theſe calces are alſo found by experiment to be ſtrongly diſpoſed to combine with animal ſubſtances; whence in many inſtances they ſerve as mordants, or the medium of union between the colouring particles and animal

animal bodies. But it has not been ſhewn that any conſiderable attraction is exerted between theſe calces and vegetable ſubſtances.

A conſiderable progreſs has been made of late years in the inveſtigation of ſuch facts as tend to afford a theory of the art of dying. The following general abſtract of this theory is taken from Berthollet.

Metallic colours muſt be diſtinguiſhed from thoſe which are peculiar to vegetable and animal ſubſtances.

The colours of metals are modified and changed by calcination, according to the degree to which it is carried.

Vegetable and animal ſubſtances may themſelves poſſeſs a peculiar colour, which varies in the different ſtates through which they paſs; or they may owe their colours to tinging particles, either combined or ſimply mixed with them. Theſe are the particles which are extracted from different ſubſtances, and which undergo different preparations, to fit them for the purpoſes of dying.

The colouring particles have chemical properties which diſtinguiſh them from all other ſubſtances: the attractions which they have for acids, alkalis, earths, metallic calces, vital air, wool, ſilk, cotton, and linen, conſtitute the chief of theſe properties.

According to the attraction which the colouring particles have for wool, ſilk, cotton and linen, they unite more or leſs readily, and more or leſs intimately with each of theſe ſubſtances; and thence ariſes the firſt cauſe of variation in the proceſſes employed, according to the nature of the ſtuff and of the colouring ſubſtance.

By the attraction which the colouring particles have for argillaceous earth and metallic calces, they form compounds with theſe ſubſtances, in which their colour is more or leſs modified, becomes more fixed, and more difficultly affected by external agents, than before. This compound being formed of principles, which have ſeparately the power of uniting with vegetable ſubſtances, and more eſpecially with animal ſubſtances, preſerves this property, and forms a triple compound with the ſtuff; and the colour which has been again modified by the formation of this triple union, acquires a greater degree of fixity, and of indeſtructibility by external agents.

The colouring particles have frequently ſo great an attraction for clay and metallic calces, that they ſeparate them from acids which held them in ſolution, and fall down with them; but the attraction of the ſtuff is ſometimes neceſſary, in order to produce this ſeparation.

The metallic calces which combine with the colouring particles, modify their colours, not only by their own, but alſo by acting upon their compoſition by means of their vital air. The change which the colouring particles thereby ſuffer, is ſimilar to that occaſioned by the air, which injures all colours more or leſs.

Of the two principles which compoſe the air of the atmoſphere, it is only the vital air, or oxygenous gas, which acts upon the colouring particles: it combines with them, weakens their colour, and renders it paler; but its action is principally exerted on the hydrogen, or inflammable air, which enters into their compoſition, and it then forms water. This effect ought to be conſidered as a true combuſtion, whereby the charcoal which enters into the compoſition of the colouring particles becomes predominant, and the colour commonly changes

to yellow, fawn colour, or brown; or the injured part, by uniting with what remains of the original colour, produces other appearances.

Light favours the combination of the colouring particles, which frequently cannot take place without its aid; and it is thus that it contributes to the deſtruction of colours. Heat promotes it alſo, but leſs powerfully than light, unleſs it has a certain degree of intenſity.

To a ſimilar combuſtion are to be attributed the effects of the pale nitrous acid, of the oxygenated or aerated muriatic acid, and even of the ſulphuric acid, when they make the colour of the ſubſtances upon which they act paſs to a yellow, and even to a black.

The effects of combuſtion may however be concealed by the vital air combining with the colouring particles, without acting particularly on the inflammable air.

Colours are more or leſs durable, or more or leſs fixed, according to the greater or leſs diſpoſition of the colouring particles to undergo combuſtion, and to allow it to go on to a more or leſs advanced ſtage.

Some ſubſtances are alſo capable of acting on the colour of ſtuffs by a ſuperiority of attraction, or by a ſolvent power; and in this conſiſts the action of acids, alkalis, and ſoap. A ſmall quantity of theſe agents, however, may ſometimes form ſupracompounds with the ſtuff, and thereby change its colour.

Metallic calces produce, in the colouring particles with which they unite, a degree of combuſtion proportioned to the quantity of vital air which can be taken from them by theſe particles.

The colours which the compounds of metallic calces and colouring particles aſſume, then, are the product of the colour peculiar to the colouring particles, and of that peculiar to the metallic calx; but the colouring particles and metallic calces muſt be conſidered in that ſtate to which they have been reduced by the diminution of vital air in the calx, and the diminution of hydrogene in the colouring particles.

Hence it follows: Firſt, that the metallic calces to which the vital air is only ſlightly attached, are not fit to ſerve as connecting mediums for the colouring particles, becauſe they produce in them too great a degree of combuſtion; ſuch are the calces of ſilver, gold, and mercury.

2d. That the calces which undergo conſiderable changes of colour, by giving off more or leſs of their vital air, are alſo bad intermediums, eſpecially for light ſhades, becauſe they produce changeable colours; ſuch are the calces of copper, of lead, and of biſmuth.

3d. That the calces which ſtrongly retain their vital air, and ſuffer very little change of colour by the loſs of a part of it, are beſt fitted to anſwer this purpoſe: ſuch is particularly the calx of tin, which quits its menſtruum eaſily, which has a ſtrong attraction for the colouring particles, and which affords them a baſis which is very white, and proper for giving a brightneſs to their ſhades, without altering them by the admixture of another colour. The calx of zinc poſſeſſes ſome of theſe qualities.

In order to account for the colours which reſult from the union of the colouring particles with the baſis which a mordant gives them, we muſt attend to the proportion in which the colouring particles unite to that baſis: thus the ſolution of tin, which produces a very copious precipitate with a ſolution of colouring particles, and thereby proves that the calx of tin enters in a large

proportion into the precipitate, has a much greater influence on the colour of the precipitate, by the whiteneſs of its baſis, than the ſolution of zinc or that of alum, which generally produce much leſs copious precipitates. The precipitates produced by theſe two laſt ſubſtances retain very nearly the natural tint of the colouring particles.

We muſt then diſtinguiſh, in the action of mordants, the combinations that may take place by their means between the colouring particles, the ſtuff, and the intermedium; the proportions of the colouring ſubſtance and intermedium; the modifications of colour, which may ariſe from the mixture of the colour of the colouring particles, and of that of the baſis to which they are united; and finally, the changes which the colouring particles may ſuffer from the combuſtion that may be produced by the intermedium.

Aſtringents do not derive their characteriſtic property from an acid, or from any other individual principle which is always the ſame, but from the property which they poſſeſs of uniting with the calx of iron, of reducing it to the ſtate of black calx, and of acquiring themſelves a dark colour, by the combuſtion they experience. Galls, which are to be conſidered as the repreſentatives of all aſtringents, readily undergo a ſlight combuſtion, which gives them a deep brown colour; but this combuſtion, which requires but a ſmall quantity of vital air, ſoon ceaſes without injuring their properties.

Galls owe their ſtability to the large proportion of charcoal they contain; and as they have the property of combining with ſome vegetable ſubſtances, with ſeveral colouring matters, and particularly with animal ſubſtances, they ſerve as intermedium for them, and impart to them their own firmneſs of colour.

E.

EAR EAR

EARTH. Chemiſts ſometimes in a groſs and inaccurate way call thoſe ſubſtances earths which remain after the volatile products of diſtillation have ariſen, and which are not ſoluble in water. This is not however ſufficiently exact, though it is difficult to exhibit a good poſitive definition. Earths are bodies ſimple with reſpect to the preſent powers of chemical analyſis, brittle, incombuſtible, infuſible by the heat of furnaces, not ſoluble in many hundred times their weight of water, and deſtitute of that opake brilliancy which characteriſes metals. There are few earthy ſubſtances which may not be reduced by analyſis to one of the five following primitive earths:—the ſiliceous, argillaceous, calcareous, ponderous, and magneſian earths; or otherwiſe, taken ſubſtantively, they are called ſilex, clay, lime, barytes, and magneſia.

The adamantine ſpar, the jargon of Ceylon, and a mineral ſubſtance from New South Wales, have afforded earthy ſubſtances which, as far as experiments

have yet determined, are different from any of theſe five. But they will not materially affect the general arrangement of chemiſtry, until future reſearches ſhall have proved that they are more abundantly found than at preſent we have reaſon to ſuſpect.

The attention of the chemical world has been ſtrongly excited by ſome experiments of Meſſ. Ruprecht and Tondi, who affirmed that they had reduced the argillaceous, calcareous, ponderous, and magneſian earths to the metallic ſtate by ſtrongly heating them with charcoal. But however probable it may be from analogy that ſuch reductions may be within the limits of poſſibility, it is now univerſally admitted, that the metal obtained in theſe experiments conſiſted of iron from the crucibles made uſe of.

In ſome ſyſtems a diſtinction is made between earths and ſtones; but this is of no utility in the enquiry reſpecting their component parts and properties. A ſtone is nothing more than a hard earthy maſs, and an earth in powder is an aggregate of very minute ſtones.

EARTH, ADAMANTINE. A peculiar earth, compoſing about one third part of the weight of the adamantine ſpar. By repeated fuſions of this ſpar with fixed alkali, and ſeparation of the known earths by ſubſequent treatment with diſtilled water and with acids, Mr. Klaproth obtained this earthy ſubſtance, diſtinguiſhable from the ſoluble earths in not yielding to the action of acids, and from ſiliceous earth in reſiſting alkalis. A further inveſtigation of its properties is wanting, but will not perhaps be eaſily obtained, on account of the ſmall attractive power which the uſual chemical ſolvents have upon it. *See* ADAMANTINE SPAR.

EARTH, ANIMAL. The fixed and inſoluble reſidues of animal ſubſtances have been diſtinguiſhed by this name, more eſpecially before their component parts had been aſcertained by late analyſis. They conſiſt of calcareous earth in combination with ſome acid. The bony coverings of ſhell-fiſh contain a large portion of mild calcareous earth, united with aerial acid or fixed air. The ſhells of eggs, of ſnails, and probably all the hard brittle external coverings of animals, are ſaid to be of the ſame nature. The baſis of bones, as well in ſea as in land animals, conſiſts of calcareous earth ſaturated with phoſphoric acid. *See* ACID PHOSPHORIC. I do not know of any experiments tending to aſcertain the preſence of any other earth, as a neceſſary component part of animal bodies, but the calcareous.

EARTH, ARGILLACEOUS. The principal natural ſpecimens of argillaceous earth are clays, properly ſo called, marles, boles, ſlates or ſchiſtus, and mica. In none of theſe, except the flag ſtone, does the argillaceous earth amount to ſo much as half their weight, though their predominating qualities appear to depend upon it. The moſt obvious characters of this earth are, an adheſion to the tongue, or any wet and ſoft body, in the more ſolid ſpecimens; and a remarkable tenacity, ductility, or kneadability ſerve to diſtinguiſh moiſtened clays in a moſt eminent degree. It is ſoluble in acids; but alkalis act much leſs upon it, either in the dry or moiſt way, than they do on ſiliceous earth. Alum is a combination of argillaceous earth with vitriolic acid. If the concrete volatile alkali be added to a ſolution of pure alum, the alkali and acid unite, while the clay falls to the bottom, united only with a ſmall quantity of fixed air. The fluid muſt be abſtracted by decantation, and the precipitate waſhed with diſtilled water, and dried.

Clays may be eaſily diffuſed and ſuſpended in water, but are not ſoluble in any ſenſible degree. The ſudden application of ſtrong heat hardens their external parts, which afterwards burſt by the exploſion of the moiſture within. By a more gradual heat pure clay contracts very much, becomes hard, and full of cracks or fiſſures. The preſence of ſiliceous earth in common clays, where it uſually conſtitutes above half the weight, renders the contraction more uniform throughout, and prevents the cracks; probably in no other way than by rendering them more numerous, and too ſmall to be perceived. When thus baked, it conſtitutes all the varieties of bricks, pottery, and porcelain. Theſe, if baked in a ſtrong heat, give fire with ſteel; a property that may be attributed to the ſiliceous earth they contain, which cannot act on the ſteel unleſs firmly ſet in the hardened clay. The dimenſions of pottery are leſs, the greater the heat to which the article has been ſubjected. On this property is conſtructed a thermometer for meaſuring the heat of furnaces, by igniting a ſmall brick of known dimenſions therein, and afterwards meaſuring its contraction. Baked clay is no longer kneadable with water, though as finely pulverized as mechanical means can go. Hence it has been inferred, that clays owe their ductility to a kind of gluten, which is ſuppoſed to be diſſipated by heat. They recover that property, however, by ſolution in an acid and precipitation; whence it ſhould ſeem to depend either on a minute portion of acid contained in clays, or the ſmallneſs of the particles when precipitated.

For the habitudes of clay with acids, ſee the ſeveral acids.—*See alſo* BRICKS, POTTERY, THERMOMETER WEDGWOODS.

EARTH, CALCAREOUS. Calcareous earth, or lime, predominates in moſt ſtones which are ſoft enough to be ſcratched with a knife. Theſe are chalk, limeſtone, marble, ſpars, gypſum, or plaſter-ſtone, and various others. As the lime is moſt frequently combined with fixed air, it is uſual for mineraliſts to drop a ſmall quantity of nitrous acid upon the ſtones they are deſirous of claſſing; and if it froths by the eſcape of the fixed air, they conclude that lime enters into the compoſition. To obtain pure calcareous earth, powdered chalk muſt be repeatedly boiled in water, which will deprive it of the ſaline impurities it frequently contains. It muſt then be diſſolved in diſtilled vinegar, and precipitated by the addition of concrete volatile alkali. The precipitate, when well waſhed and dried, will conſiſt of lime united to fixed air; the latter of which may be driven off by heat, if neceſſary.

If chalk, marble, limeſtone, ſpar, or any other ſpecimens of this earth, containing fixed air, be expoſed to continued ignition, they give out fixed air and water, to the amount of near half their weight. The remainder, conſiſting chiefly of lime, has a ſtrong tendency to combination, and attracts water very powerfully. The addition of water to lime produces a very conſiderable heat, attended with noiſe, and agitation of the parts, which break aſunder; and a phoſphoric light is ſeen, if the experiment be made in the dark. Lime thus ſaturated with water is ſaid to be ſlaked. Water diſſolves about one ſeven-hundredth part of its weight of lime, and is then called lime-water. This ſolution has an acrid taſte, and turns ſyrup of violets to a green colour. If lime-water be expoſed to the open air, the lime attracts fixed air, and is by that means converted into chalk; which, not being ſoluble in water, forms a cruſt on the ſurface, formerly called cream of lime, that, when of a certain thickneſs, breaks, and falls to the bottom: and in this way the whole of the lime will in time

time be ſeparated. If the fire has been too violent in the burning of lime, the ſtone becomes hard, ſonorous, and incapable of abſorbing water with the requiſite degree of avidity. This effect ſeems to ariſe from part of the calcareous earth having entered into fuſion with the clay, flint, or other contaminating earths, with which it forms a glaſs that covers and defends the reſt.

The paſte of lime and water, called mortar, has a degree of adheſion and ductility, though much leſs than clay. When dry, it is more or leſs friable, like chalk. A mixture of ſand, or broken earthen veſſels, greatly increaſes its firmneſs, which it ſeems to effect by rendering it more difficult for the parts to be removed with reſpect to each other. When mortar is left to dry by the gradual evaporation of its ſuperfluous water, it is very long before it obtains its utmoſt degree of firmneſs. But if dry quick-lime be mixed with mortar, it gradually abſorbs the ſuperfluous water, and the maſs becomes ſolid in a very ſhort time.

Gypſum, or plaſter of Paris, conſiſts of lime united to the vitriolic acid, together with water. If this ſubſtance be expoſed to a moderate heat, part of the water is driven off with an appearance reſembling ebullition. The dry powder which remains may be mixed with water to the conſiſtence of thin paſte, and poured into a mould; and ſoon afterwards it ſuddenly becomes ſolid; at the ſame time that it is a little heated, and its bulk ſomewhat increaſed. This effect may be explained by obſerving that the particles of the gypſum are at firſt ſimply wetted by the water, in the ſame manner as happens with clay; and for that reaſon no other effect takes place, than the production of an imperfect degree of fluidity, from the motion of the parts among each other being facilitated: but when the water, by the gradual progreſs of the action between it and the dried gypſum, becomes combined in the ſame manner as before the calcination, it is abſorbed, and enters into the compoſition of a ſolid body; the imperfect fluidity ariſing from the preſence of uncombined water diſappears, heat is developed, and the whole maſs takes the ſolid form.

If the heat be ſtrong, or continued any conſiderable time after the appearance of ebullition has ceaſed, the ſelenite will be partly decompoſed by the loſs of ſome of its vitriolic acid, and the plaſter will be unfit for this purpoſe. The uſe of plaſter in caſting ſmall ſtatues, medallions, and other ornaments, is well known.

From various pertinent obſervations, Chaptal has ſhewn that gypſum is formed by the gradual decompoſition of pyrites, which form vitriolic acid. This being carried off by water, takes up lime in its courſe, and the combination is afterwards depoſited in conſequence of the ſpontaneous evaporation of the water.

Calcareous earth, though infuſible in the ſtrongeſt heats of our furnaces, is nevertheleſs a very powerful flux with regard to mixtures of the other earths. Theſe are all fuſible by a proper addition of calcareous earth. Compounds are ſtill more fuſible; for any three of the five well-known earths may be fuſed into perfect glaſs, if they be mixed together in equal portions, provided the calcareous be one of them.

The earthy part of animals is chiefly, if not altogether, calcareous: in moſt caſes it is united with phoſphoric acid, but frequently with fixed air. *See* EARTH, ANIMAL.

EARTH, FULLERS. Among the uſeful reſearches, for which we are indebted

debted to the illuſtrious Bergman, we find one upon Lithomarga*, or ſtone marle; which ſeems to differ from common marle in its compoſition, chiefly in poſſeſſing a much larger portion of ſiliceous, and leſs of calcareous earth. Fullers earth is one of the moſt uſeful varieties of Lithomarge.

Cronſtedt deſcribes † Lithomarge under the following general characters: Firſt, When dry, it is ſmooth and ſlippery like hard ſoap. Secondly, It is not perfectly diffuſible in water; but when immerſed in that fluid it falls into pieces of greater or leſs magnitude, or in ſuch a manner as to aſſume the appearance of curds. Thirdly, In the fire it eaſily melts into a white or reddiſh frothy ſlag, which is conſiderably larger than before, in conſequence of its poroſity. Fourthly, Its fracture is irregularly convex or concave.

This author deſcribes only the Lithomargæ of Oſmund, of Tartary, and of Lemnos; the Hampſhire fullers earth not having come to his hands, probably on account of the ſevere penalties impoſed by the Engliſh legiſlature on its exportation. Bergman examined them all, except the ſecond, which is the Keffekil of the Crim Tartars, who are ſaid to uſe it inſtead of ſoap, and of which he was not provided with a ſample. Wiegleb, in Crell's Journal, quoted by Kirwan ‡, found that it conſiſts of equal parts magneſia and ſiliceous earth.

The Lemnian earth, highly eſteemed for many centuries for its ſuppoſed medical virtues, and till lately ſold in Europe under the ſeal of the Grand Signor, has the external appearance of clay with a ſmooth ſurface, reſembling agate, eſpecially in its recent fractures, which are uſually either concave or convex. It may be ſcraped with the nail, is compoſed of impalpable particles, though a little gritty between the teeth, under which it feels like tallow. When immerſed in water, it is ſpontaneouſly divided into ſmall pieces with a ſlight crackling noiſe, but they do not become ſo ſmall as to be inviſible or impalpable. Pulverization and boiling in water diffuſes it in the fluid, which paſſes almoſt perfectly clear through doubled filtering paper. The water examined by the uſual teſts is found to be neither acid nor alkaline, but exhibits the preſence of marine acid in combination.

This earth removes impurities like ſoap, though it affords no froth. When urged by the blow-pipe, it does not decrepitate, but turns black, melts with ebullition, and becomes converted into a dark frothy ſlag. With microcoſmic ſalt there is a commencement of ſolution with efferveſcence; but the remainder is ſcarcely affected. Borax acts more effectually, though ſlowly, on the reſiduum. Mineral alkali occaſions a conſiderable efferveſcence with noiſe. By the humid analyſis, Bergman found it to contain forty-ſeven parts in the hundred ſiliceous earth, $5\frac{4}{10}$ of mild calcareous earth, $6\frac{2}{10}$ of mild magneſia, 10 of argillaceous earth, $5\frac{4}{10}$ calx of iron, and 17 of moiſt volatile matter expellable by drying.

The Oſmundic earth comes from mount Oſmund, in the pariſh of Ratwick in Eaſt Dalecarlia. Its colour is grey, like cinders, its ſurface rough, and as if greaſed. It is harder than the Lemnian earth, breaks into angular pieces, adheres ſtrongly to the lip, and is more gritty between the teeth than that earth. In water it ſeparates into ſmaller particles, and is detergent.

This earth decrepitates before the blow-pipe, turns black, and melts with ebullition, leaving a white frothy ſlag. It exhibits the ſame phenomena as the Lem-

* In the third vol. of his Eſſays, Eng. tranſlation. † Magellan's Eng. ed. i. 234. ‡ Mineralogy, p. 60.

nian

nian earth with the blow-pipe; but a grain of it thrown into the ſolution becomes white. It effervesces leſs with the mineral alkali.

From the humid analyſis, Bergman found one hundred parts of the Oſmundic earth to contain 60 parts white ſiliceous powder, $5\frac{7}{10}$ calcareous earth, $0\frac{5}{10}$ magneſia, $1\,1\frac{1}{10}$ argillaceous earth, $4\frac{7}{10}$ calx of iron, and 18 of moiſt volatile matter.

The Hampſhire fullers earth, examined by Bergman, was of a dark colour, a little inclined to green, and faintly marked with yellowiſh veins, leſs hard than the Oſmundic and Lemnian earths, capable of being poliſhed with the nail, of a rough fracture with dark pointed eminencies, adhering to the lip, and a little ſiliceous between the teeth. When immerſed in water, it fell to pieces like the other earths. It produced no froth when rubbed with water, but was exceedingly detergent.

Water in which pulverized fullers earth was boiled, paſſed ſtill turbid through ſeveral folds of paper, and the water indicated the preſence of combined marine acid. Before the blow-pipe it decrepitated, but leſs than the Oſmundic earth; after which it turned black, was fuſed with ebullition into a dark-coloured ſpongy maſs. Its habitudes with borax, microcoſmic ſalt, and mineral alkali, were the ſame as thoſe of the Lemnian earth.

Bergman's method of analyſing this and the two preceding earths was the following: An hundred parts or docimaſtic pounds of the earth were pulverized, and inſerted into a ſmall glaſs cucurbit with twice its weight of highly concentrated vitriolic acid; after which a capital and receiver being adapted, the diſtillation was performed on a ſand bath. An acid vapour aroſe by the firſt gentle heat, which was found to be marine acid; doubtleſs, ſays Bergman, ariſing from decompoſed ſea-ſalt. A greater heat did not exhibit any ſigns of volatile alkali. He then decanted off the ſuperfluous acid, waſhed the reſiduum in diſtilled water, dried it, and found its weight. This was found to be ſiliceous earth contaminated with iron.

The next object conſiſted in aſcertaining the contents of the acid which had been decanted off. For this purpoſe he divided it into two parts. To one part, made very warm, he gradually added finely pulverized chalk, taking great care not to exceed the due quantity. The chalk precipitated whatever clay or iron might be preſent; but left the magneſia in ſolution, becauſe the ſum of the quieſcent attractions of lime to fixed air, and vitriolic acid to magneſia, are greater than the divellent attractions of the fixed air to magneſia, and vitriolic acid to lime; ſo that the preſence of the fixed air prevented that decompoſition of vitriolated magneſia which would have taken place if mere lime had been uſed.

After the precipitation of clay and iron from the ſolution he evaporated the liquor, which occaſioned the ſeparation of vitriolated lime or ſelenite, and vitriolated magneſia, or Epſom ſalt; the latter of which, on account of its much greater ſolubility, was taken up by a little warm water. Another evaporation and ſolution of the Epſom ſalt was made, to clear it entirely of the ſelenite. Mild fixed alkali was uſed to precipitate the earths from the reſpective ſolutions of theſe two ſalts, and the remaining liquors were ſubjected to ebullition for a quarter of an hour, to throw down the ſmall portion of earth which might be ſuſpended by the redundant fixed air. In this way, conſequently, the true quantities by weight of magneſia and of lime, contained in half the centenary, were aſcertained, taking care to deduct the weight of chalk made uſe of in the precipitation.

In

In the foregoing proceſs the iron and clay were precipitated, that they might be no impediment to an examination of the quantities of lime and magneſia. The ſeparation of the clay from the iron not being a very direct operation, the other half of the original ſolution was reſerved for the purpoſe of determining their weights. Pruſſian alkali was therefore added to this half of the ſolution; in conſequence of which the iron fell down in the form of Pruſſian blue, leaving the earths ſuſpended. The quantity of iron was determined by allowing ten grains of iron for each fifty-nine grains of blue precipitate.

In the next place the ſolution was filtered, now containing clay, magneſia, and lime, all combined with vitriolic acid; out of which the quantity of the firſt only was required to be found. The ſolution was therefore concentrated by evaporation, and the exceſs of acid then ſaturated, by the addition of mild magneſia, till paper ſtained with turnſole was not affected by it. An exceſs of magneſia was guarded againſt, by ſuffering each ſmall portion to be entirely diſſolved before any more was added. After half an hour's boiling, the neutral combination of clay and vitriolic acid fell down, it being well known that the ſolubility and other properties of alum depend on its exceſs of acid: and this combination being digeſted with mild fixed alkali afforded the pure argillaceous earth.

By this management he found that the Hampſhire fullers earth contained of ſiliceous earth $51\frac{8}{10}$ parts; of mild calcareous earth $3\frac{3}{10}$; of mild magneſia $0\frac{7}{10}$; of argillaceous earth 25; of calx of iron $3\frac{7}{10}$; and of moiſt volatile matter $15\frac{5}{10}$ parts.

The properties required in a good fullers earth are, that it ſhould contribute to the waſhing away all impurities, and promote that curling and intermixture of the hairs of the woollen cloth, which thicken its texture, and give it the deſired firmneſs. Both probably depend on its detergent quality, that clears away all the unctuous matter of the wool, and renders its parts capable of becoming more perfectly entangled together by the mechanical action of fulling; an effect not ſo likely to take place when the fibres or hairs are diſpoſed by greaſe to ſlide eaſily over each other. The detergent power reſides in all clays, but is doubtleſs greatly increaſed by the ſiliceous earth, which may be conſidered as the bruſh, while the clay ſerves as the ſoap. This is familiarly ſhewn, by the common practice of adding ſand to ſoap, which renders it much more detergent; but at the ſame time more capable of injuring the ſubſtances to which it is applied, and that more eſpecially when the ſand is coarſe. Fullers earth is bad, if the ſand be not exceedingly fine; and the ſuperior excellence of the Hampſhire fullers earth ſeems to depend more on the fineneſs of its parts than on their proportions, as is ſhewn by the experiment of boiling it in water; after which it paſſes more plentifully through the filter than any of the other lithomargæ.

EARTH, FUSIBLE, OF WEDGWOOD. Some mineral matter from New South Wales was put into the hands of Mr. Wedgwood*, by Sir Joſeph Banks. It conſiſted of a mixture of fine white ſand, a ſoft white earth, ſome colourleſs micaceous particles, and a few black ones, reſembling mica or black lead. Mr. Wedgwood made ſome experiments upon it, but does not appear to have completely analyſed the maſs, probably on account of its ſmall quantity.

Neither the nitrous nor vitriolic acids, concentrated or diluted, hot or cold,

* Philoſ. Tranſ. for 1790, page 306.

were

were found to take up any thing from this mineral, which could be precipitated by alkalis; excepting that the ſtrong vitriolic acid, by due management, indicated a minute proportion of clay. But the marine acid by digeſtion near its boiling heat acted on it with frequent exploſive burſts, and took up about one-fifth of the whole. The crude mineral pulverized, loſt its blackneſs by calcination, and one-fourth of its weight, but was ſtill found to be as difficult of ſolution as before. Water added to the marine ſolution threw down a white precipitate; and the ſeparation was ſo complete, that, after an addition of eight or nine times the whole bulk of water, there remained nothing in ſolution that alkali could precipitate. This white matter was inſoluble in water, and alſo in the nitrous or vitriolic acids, and in alkaline ſolulutions. Strong marine acid took it up as before, with the aſſiſtance of the ſame degree of heat. A certain preciſe quantity of nitrous acid, added to the marine ſolution, kept the white matter ſuſpended, even when diluted with water. Strong vitriolic acid did not throw down the white matter from the marine ſolution; but when the quantity added was nearly equal to that of the ſolution, part of the marine acid was extricated in white fumes, with efferveſcence. The mixture heated nearly to boiling became tranſparent, and continued ſo in the cold. This ſolution is alſo precipitable by water, and the precipitate is ſoluble in marine acid.

The ſaturated marine ſolution does not cryſtallize by evaporation, but affords a deliqueſcent maſs, which is not corroſive, and parts with its acid in an heat near ignition. Pruſſian alkali does not precipitate the marine ſolution; but all the alkalis, whether mild or cauſtic, occaſioned copious precipitations, which were ſoluble in marine acid, and thence precipitable by water in the original ſtate.

This white precipitate is much more fuſible than any of the other ſimple earths; whence it may with propriety be called the fuſible earth, as we have ventured to denominate it in the title. In an heat between 142 and 156 degrees of Wedgwood's thermometer, which is nearly as high as the utmoſt heat of a ſmall air furnace, it melted in contact with clay, with flint, with chalk, with lime, with magneſia, with pure ponderous earth, and with ponderous ſpar, in ſo many different experiments. In an hole ſcooped in chalk it ran into a ſmooth whitiſh opake bead, not at all adherent to the chalk itſelf; and in a cavity in charcoal it likewiſe fuſed, but did not ſeem to undergo any revivification. Part of this was ſoluble in boiling marine acid, as at firſt; but an accident prevented the determination whether the whole was ſoluble.

From theſe experiments Mr. Wedgwood thinks it proper to conſider the white matter as a new earth, directly ſoluble in no menſtruum but marine acid, and perhaps its compounds; not cryſtallizable in this combination; precipitable by water, and not by Pruſſian alkali; parting with its acid in an heat below ignition, and fuſible in a degree of heat not very much exceeding that required to melt crude iron.

The black ſubſtance which ſeems to have compoſed about one-fifth part of the crude mineral was found to reſemble plumbago in its leading properties, but the reſidue did not appear to be iron. The remaining three-fifths of the mineral, which reſiſted the humid attacks in Mr. Wedgwood's experiments, were probably ſilex; but he does not ſpeak of any direct examination of its properties, by fuſion with alkalis, treatment with the acid of ſpar, or otherwiſe.

EARTH, GYPSEOUS. Before the component parts of gypſum or plaſter of Paris were clearly aſcertained, ſome chemiſts conſidered its earth as a peculiar genus. But ſince this compound has been proved to conſiſt merely of lime and vitriolic acid, the term of courſe was rejected.

EARTH, OF THE JARGON. The jargon of Ceylon is a precious ſtone, of a pale yellowiſh green colour inclining to red; forming upon the whole a kind of ſmoky grey tinge. Its regular figure is that of a four-ſided priſm, terminating in two obtuſe pyramids, compoſed each of four iſoſceles triangles. Its ſpecific gravity is greater than that of any other ſtone, being 4,615.

Mr. Klaproth * examined this ſtone, and diſcovered a peculiar earth. Pieces of the ſtone were ignited, thrown into water to render it leſs coherent, and then levigated upon porphyry. The powder was then fuſed in a ſilver crucible with a large portion of cauſtic fixed alkali. The ſolution was treated with water and with marine acid, which took up a ſmall part, and left a reſidue, which was again fuſed with alkali and treated as before. By ſeveral repetitions of this proceſs the whole was diſſolved. By ſaturating the acid with mild vegetable alkali, the earthy matter was thrown down. Digeſtion of part of this precipitate with marine, and part with vitriolic acid, indicated, after a due application of chemical methods, a conſiderable portion of ſiliceous earth, with a minute quantity of iron and nickel, and a much larger portion of earth, which remained ſuſpended on account of its ſolubility in acids. This earth was found to differ in its properties from every other yet known. Its ſolubility in acids ſufficiently diſtinguiſhes it from ſilex: when precipitated by mild alkali, it did not become effervescent like magneſia or lime; neither did it like them form Epſom ſalt or ſelenite with the vitriolic acid. It did not, like clay, form alum with that acid. Pruſſian alkali did not precipitate it like ponderous earth, neither did it form the ponderous ſpar, when combined with vitriolic acid. When this earth was treated by the blow-pipe, it was not found to be ſoluble either in microcoſmic ſalt or mineral alkali; but borax diſſolved it. The contents of the jargon were in the centenary 31½ parts ſilex; ½ part calx of iron containing nickel, and 68 parts of this peculiar earth.

EARTH LEMNIAN, *or* TERRA LEMNIA. A bolar earth from the iſland of Lemnos, formerly in great eſteem for its ſuppoſed medical qualities. Cronſtedt reckons it among the lithromargæ or ſtone marrow. Bergman has given a good analyſis of it; for which ſee EARTH, FULLERS.

EARTH, MERCURIAL. A ſubſtance which, according to Becher and other alchemical philoſophers, is a common principle of metals and ſome other bodies. In conformity with this obſcure theory, we find frequent mention of the mercuries of gold, of ſilver, or of other metals. The facts and diſcoveries ſubſequent to the time of the illuſtrious Becher have not afforded any foundation to conclude that any ſuch common principle as the mercurial earth exiſts; and it was ſo far from being ſatisfactorily exhibited by Becher himſelf, that his diſciple, the great Stahl, did not include it in his modification of the Becherian ſyſtem.

EARTH, MAGNESIAN. This earth, which is ſubſtantively called magneſia, and likewiſe, but not frequently, the muriatic earth, is of modern diſcovery. Bergman has written a treatiſe upon it in his uſual maſterly manner. It firſt began to be known at Rome under the name of Count Palma's powder, where it was offered by a regular canon as a remedy for all diſorders. Its reſemblance in many reſpects to calcareous earth, induced many to conſider it at firſt as the ſame thing; but Mr. F. Hoffman firſt proved it to be eſſentially different. This

* See the Memoir in the Journal de Phyſique, for March 1790.

was afterwards diſcovered by Dr. Black of Edinburgh, and Margraaf of Berlin, unknown to each other.

Magneſia may be prepared in various ways; but the preſent is precipitated from Epſom ſalt by the addition of an alkali. A little more than half its weight of ſalt of tartar, is ſufficient for this purpoſe; but potaſh is more generally uſed for the ſake of cheapneſs; of which, on account of its impurity, a double quantity is required. Both the ſalts are to be diſſolved in at leaſt twice as much water as will ſuſpend them. After filtration they are to be mixed and boiled, then ſet by at reſt till the magneſia is precipitated. This, after decantation of the ſupernatant fluid, is to be edulcorated by ſeveral waſhings with water, and laſtly dried upon a filter or cloth; it is the mild magneſia. Bergman informs us, that one hundred parts of Epſom ſalt afford about forty-two of this mild magneſia, but only twenty-five of ſuch as does not effervеſce with acids, the difference depending on the ſtate of the precipitating alkali. If this laſt be mild, or contain fixed air, fifty-eight parts are neceſſary, and the magneſia is mild; but if it be cauſtic, forty-five parts will be ſufficient. The double portion of water is uſed, in order that there may be ſufficient to diſſolve the vitriolated tartar, which is formed by the vitriolic acid of the Epſom ſalt on its union with the alkali, and the boiling is required to prevent a part of the magneſia from being ſuſpended by a portion of the extricated fixed air.

The mother waters of nitre or ſea-ſalt contain magneſia, which may be obtained by precipitation. The former is moſt impure, more eſpecially on account of an abundant portion of lime.

The impurity of the alkalis made uſe of, and other circumſtances, affect the magneſia to be met with in commerce. To have it pure, a ſolution of pure Epſom ſalt muſt be precipitated by mild volatile alkali; and the mild magneſia which falls down muſt be frequently waſhed, and then deprived of its fixed air and water by a red heat.

Mild magneſia is a light impalpable powder of a white colour, and forms a paſte with water which has not much coheſion. When deprived of its fixed air by heat, it is harſher to the touch, but is not cauſtic nor ſoluble in water like lime. It does not attract fixed air ſo ſtrongly as to take it from any alkali but the volatile by ſimple attraction. It does not precipitate lime water, but throws down all the metals from their ſolvents. It is very ſoluble in acids.

The common magneſia ſhews ſigns of fuſion in a ſtrong heat; but that which is pure reſiſts the moſt powerful focus of the burning glaſs, without either contracting in its dimenſions *, or undergoing any other change. It flows eaſily with borax and the microcoſmic ſalt: with equal parts of flint and borax it aſſumes the form of a beautiful coloured glaſs, reſembling the topaz. With equal parts of flint and fluor ſpar it affords a glaſs reſembling the chryſolite: and with an equal portion of fluor alone it corrodes and runs through the crucible. Almoſt any proportion of lime, pure clay, and flint is made to flow in the fire; and with four times its weight of green glaſs it affords a maſs reſembling porcelain, and hard enough to give fire with ſteel. It will not flow with an equal weight ſingly, either of flint, quicklime, ponderous earth, glaſs, lead, vegetable alkali, or of vitriolated tartar. But common clay runs with it into an hard maſs.

Bergman found that one hundred parts of mild magneſia contain twenty-five

* Magellan's Cronſtedt, art. Magneſia.

parts acid, thirty water, and forty-five of pure magnesia; that it is sparingly soluble in water, but more plentifully when the water is impregnated with fixed air, and the magnesia very finely divided, as in the case of precipitation in the cold, by a mild alkali. Fourcroy*, who has paid particular attention to the precipitation of magnesia, found that perfectly mild vegetable alkali affords no precipitate when added to a solution of Epsom salt, at the temperature of 60°. The mineral alkali, which contains less fixed air than the crystallized vegetable alkali, was likewise found to afford but a small quantity of precipitate, unless heat was applied. Mild volatile alkali exhibited the same property. No precipitate was afforded by this salt in the cold: at a medium heat the magnesia was separated, and at a boiling heat it was again taken up, most probably in consequence of a triple combination of volatile alkali, vitriolic acid, and magnesia, having been formed. The saline combination of fixed air and magnesia was separated in crystals from all these solutions, by standing uncovered; during which time the abundant fixed air which held the magnesian salt in solution was, no doubt, gradually dissipated. The crystals afforded, when vegetable alkali was used, were contaminated with vitriolated tartar, which separates at the same time: those obtained by means of the mineral alkali are finer and purer; but the most beautiful were obtained by leaving the solution, to which volatile alkali had been added, exposed for some days in an oblong vessel.

This crystallized aerated magnesia has usually the form of six-sided prisms. It is almost tasteless, effloresces in the air, becomes pulverulent when heated, by the loss of its fixed air and water, and is soluble in about forty times its weight of water, at the temperature of 55°. Half its weight consists of fixed air, one fourth water, and one fourth magnesia. The magnesia in this salt is therefore combined with near twice as much fixed air, and more than three times as much water as are contained in the mild magnesia of Bergman.

There is scarcely any combination of magnesia which does not remarkably differ from those of lime, with which it was formerly considered to be identical. With vitriolated acid it forms Epsom salt, which is bitter and very soluble, whereas lime affords gypsum, tasteless and almost insoluble. With nitrous acid it affords a crystallizable salt. Lime does not. With marine acid it forms a combination easily deprived of its acid by mere heat. With vinegar it affords no crystals, and its elective attractions are likewise very different from those of lime. Alkalis have little or no action on magnesia in the humid way.

Magnesia combines very sparingly with sulphur in the dry as well as in the humid way, and the combination possesses the hepatic characters.

Though this earth appears to be very extensively diffused over the surface of the globe, yet it is undoubtedly less plentiful than the calcareous, siliceous, or argillaceous earths. Most of the native specimens of the magnesian genus are remarkable for a certain soapy or greasy feel. Of these the most common are steatites of a greenish colour, and soft enough to be scraped with the nail; soap rock, lapis ollaris, or Spanish chalk, of a yellow or whitish colour, or black, though rarely, rather harder than steatites, and so easily wrought and turned that pots are made of it. Asbestos, amianthus, and the Venetian and Muscovy talc are included in this genus.

EARTH PONDEROUS. This earth owes its denomination to the un-

* Annales de Chemie, ii. 282.

common

common weight of its combination with vitriolic acid, which is more plentifully met with than any other, and known by the names of ponderous ſpar, or marmor metallicum. This combination is found either tranſparent or opake. The tranſparent ſpar in its uſual form is of a ſix-ſided very flat priſm, ending in a four-ſided pyramid; but, like all other cryſtals, liable to be varied by the circumſtances attending their formation. The opake ſpecimens, called cawk by the miners, are of a white, grey, or fawn colour; frequently of no regular figure, but often in the peculiar figure of a number of ſmall convex lenſes ſet in a ground. Moſt ſpecimens of this earth are more than four times as heavy as an equal bulk of water; which conſtitutes an eſſential difference between them and thoſe of the calcareous genus, becauſe theſe laſt are little more than twice the weight of the water they diſplace on immerſion. The lime ſtone, or lapis hepaticus, contains about one third part of this earth. And it is alſo found combined with fixed air in the mine of Anglezark, near Chorley in Lancaſhire*, and alſo at Strontian and Dunglaſs, near Dumbarton in Scotland.

To obtain ponderous earth in a diſengaged ſtate, the heavy ſpar or vitriolated ponderous may be fuſed with about twice its weight of mild fixed alkali, which will combine with its acid and form a neutral ſalt, to be waſhed off by water; while the ponderous earth remains behind in combination with fixed air. A ſtrong heat drives off the fixed air, and leaves the ponderous earth in a ſtate perfectly reſembling quicklime in taſte, and exhibiting the ſame phenomena with water. This artificial combination of fixed air and ponderous earth differs from the natural in the remarkable circumſtance, that the latter contains no water; and to this it ſeems to be owing that the natural combination does not loſe its acid by mere heat.

Great as the reſemblance is between ponderous earth and lime in many reſpects, yet in others it differs ſo much as to ſhew that they are by no means the ſame ſubſtance. It is ſoluble in about nine hundred times its weight of water, when pure; but requires near twice as much when combined with fixed air, though an exceſs of this acid renders it more ſoluble. Its attraction to the vitriolic acid is ſtronger than that of any other ſubſtance, inſomuch that it affords the beſt teſt of the preſence of that acid in waters or elſewhere. With the nitrous and marine ſalts it affords cryſtallizable ſalts. The marine ſolution is commonly uſed as the teſt liquor for diſcovering vitriolic acid. Ponderous earth affords a deliqueſcent ſalt with acetous acid. It takes the vitriolic acid from its combination with lime; and lime, on the other hand, takes the ſaccharine acid from its combinations.

This earth forms an hepatic combination, when treated with ſulphur.

No other earth is precipitated by the Pruſſian alkalis; whence it has been ſuſpected to poſſeſs a metallic nature, though no one has yet ſucceeded in reducing it.

It is not fuſible alone by the ſtrongeſt heat. The famous Bolognian phoſphorus conſiſts of the vitriolated ponderous earth ignited for a time with ſome combuſtible ſubſtance. For this purpoſe the ſpar is pulverized, then kneaded up with mucilage of gum tragacanth, and formed into pieces as thin as the blade of a knife. Theſe pieces are afterwards dried and ſtrongly coloured by placing them in the midſt of the coals of a furnace. The pieces are cleared of the aſhes by blowing on them with bellows. In this ſtate if they be expoſed to the light for a

* Mancheſter Memoirs, iii. 599. A very excellent analyſis of this aerated ponderous earth, by Dr. Withering, is inſerted in the Phil. Tranſ. for 1784.

few

few ſeconds, and afterwards carried into a dark place, they ſhine like glowing coals; they even ſhine under water. In proceſs of time they loſe this property; but it may be reſtored by a ſecond heating. *See* BOLOGNIAN STONE.

EARTH, PORCELAIN. A fine white clay; the Kaolin of the Chineſe. All natural clays contain a large proportion of ſiliceous earth; and the ſuperior excellence of this clay for potters uſe, ſeems to depend in a great meaſure on the fineneſs of its ſiliceous ingredient. It abounds in particles of a micaceous nature; and having no oily or bituminous matter in its compoſition, it retains its colour in every degree of heat.

EARTH, SILICEOUS. The moſt eminent characters of this earth are its hardneſs and inſolubility in almoſt every acid. It exiſts nearly in a ſtate of purity in rock-cryſtal, and abounds in all natural bodies which are hard enough to ſtrike fire with the ſteel. In the pulverulent form it poſſeſſes a ſingular degree of aſperity to the touch, and has not the leaſt diſpoſition to adhere and become kneadable by the addition of water. It has been thought however, by Bergman and others, that water may diſſolve a minute proportion of it. *See* CRYSTAL ROCK. No acid diſſolves it but that of the fluor ſpar, which ſuſpends it abundantly while in the aeriform ſtate, leſs ſo when diſſolved in hot water, and very ſparingly when cold. Alkalis diſſolve it both in the humid and the dry way. In the humid way they combine with about one-ſixth part of their weight*, when the ſiliceous earth is in a ſtate of extreme diviſion. And in the dry way they take up a very large proportion, according to the degree of heat made uſe of. From one to two parts of alkali, with one part of ſilex, form hard permanent glaſs; but if the ſalt exceed this proportion, the compound will attract humidity from the air, and aſſume the liquid ſtate. This fluid, or combination of ſilex with water by the medium of alkali, is known by the name of the liquor of flints. The addition of an acid will ſeize the alkali, and throw down the ſiliceous earth in a ſtate of purity; and accordingly this is the proceſs by which it is to be obtained in a diſengaged ſtate. That is to ſay, let rock-cryſtal be diſſolved by ſtrong fuſion in four times its weight of fixed alkali, and the maſs diſſolved in water; let marine acid be then added in exceſs; this will ſeize the alkali, and form ſoluble ſalts with any other earths that may be preſent; but the ſiliceous earth will fall to the bottom. Repeated ablutions in diſtilled water will ſeparate all the extraneous ſaline fluid which may be interpoſed between theſe particles after decantation, and the dried powder will conſiſt of pure ſiliceous earth.

Pure ſiliceous earth has not been fuſed either by the heat of a furnace or of the burning mirror; but rock-cryſtal was fuſed by Profeſſor Errhmann, by means of a flame urged by a ſtream of vital air. With borax it is eaſily fuſed; but requires a longer time with microcoſmic ſalt. With metallic calces, more eſpecially thoſe of lead, it combines by fuſion, and forms glaſs of a denſe texture and ſtrong refractive power. *See* GLASS.

Rock cryſtal, quartz, flint, gritſtone, jaſper, and moſt of the precious ſtones or gems, owe their diſtinguiſhing qualities to ſiliceous earth, and are therefore conſidered as ſpecimens of this genus. The reſpective titles of theſe may be conſulted for accounts of their component parts and habitudes.

EARTH, VEGETABLE. This appellation has been given to the inſoluble

* Chaptal, Elements of Chemiſtry. Eng. Tranſlation, ii. 15.

reſidue

reſidue which remains after the incineration of vegetables, and likewiſe to the mould or ſoil beſt ſuited to the propagation and growth of theſe organized beings.

Vegetables contain but a ſmall proportion of earth of any kind, the much greater part of their ſubſtance being found by experiment to conſiſt of water, fixed air, and inflammable air, in the concrete or combined ſtate, as remote principles, a ſmall portion of fixed alkali, uſually either neutralized by the vegetable acids or combined with the oils or mucilage, and a few other neutral ſalts.

The earth of vegetables is for the moſt part either calcareous, or a mixture of various earths, and ſometimes of the calces of iron and manganeſe, in different proportions, according to the ſpecies of the vegetable. Theſe earths may be obtained either by incineration or putrefaction, and are not therefore the product of the fire.

Vegetable mould or earth, as far as the ſame may conſiſt of fixed parts, appears therefore, from theſe analytical facts, to be merely the vehicle by which the aqueous or aërial ſubſtances are conveyed into the veſſels of plants. Other ſynthetical experiments of plants ſupported and nouriſhed by the mere immerſion in water, and ſome which thrive, though their roots and branches have no other body in contact with them but the air of the atmoſphere, are ſufficiently ſtrong in confirmation of this truth.

Chaptal * has treated this ſubject in a manner ſo ſingularly perſpicuous and conciſe, that I ſhall follow him in the remainder of the preſent article.

Although it is well proved that pure water is ſufficient for the ſupport of plants, it muſt not be concluded that the ſoil or earth is of no utility. Its uſe is ſimilar to that of the placenta, which of itſelf affords no ſupport to the fœtus, but prepares and diſpoſes the blood of the mother to become a ſuitable nutriment; or it reſembles, in its uſeful application, the various receptacles which are placed in the human body, to preſerve the ſeveral humours, and emit them when required. The earth imbibes and retains water. It is the reſervoir deſtined by nature to preſerve the elementary fluid which the plant continually requires, and to ſupply it in proportion to its wants, without expoſing it to the equally fatal alternatives of being either inundated or dried up.

We may even obſerve that the young plant or embryo of a vegetable is not entruſted by nature with the labour of digeſtion. The ſeed is formed of a parenchyma which imbibes water, elaborates it, and does not tranſmit it to the germen until it is converted into an humour of a ſuitable quality. By inſenſible gradations this ſeed is deſtroyed; and the plant having become ſufficiently ſtrong, is left to perform the digeſtive function without farther aſſiſtance. So likewiſe it is that we obſerve the fœtus ſupported in the womb by the fluids of the mother herſelf; but when it has ſeen the light, it receives for its nouriſhment a fluid leſs animalized, its organs are gradually ſtrengthened, and at length become capable of digeſting a ſtronger and leſs aſſimilated nutriment.

But on this very account, namely, that the earth is deſtined to afford a due ſupply of water to the plant, the nature of the ſoil cannot be a matter of indifference, but muſt be varied accordingly as the plant requires a more or leſs conſiderable quantity of that fluid in a given time, in proportion to the magnitude and extent of its roots.

A proper ſoil is that, 1ſt, which affords a ſupport to the plant, of ſufficient

* Elements of Chemiſtry, III. 26. the whole ſection well deſerves to be conſulted.

firmneſs

firmneſs to prevent its being too much agitated, or overthrown, by the winds or other cauſes; 2d, which is capable of admitting the roots to be eaſily extended; 3d, which is ſuited to receive and abſorb moiſture, that the plant may on no occaſion ſuffer from the want of this eſſential requiſite. To anſwer theſe conditions, it is neceſſary to make a due mixture of the primitive earths, becauſe no one in particular is equal to the accompliſhment of them. Siliceous and calcareous earths may be conſidered as hot and drying, the argillaceous as moiſt and cold, and the magneſian as poſſeſſing intermediate properties. Each in particular has its imperfections that render it unfit for culture. Clay abſorbs water, but does not communicate it; calcareous earth receives and gives it too quickly; but the properties of theſe earths are ſo happily oppoſed that they correct each other by mixture. Accordingly we find, that by adding lime to an argillaceous earth, this laſt is divided; and the drying quality of the lime is mitigated, while the ſtiffneſs of the clay is diminiſhed. On theſe accounts alſo it is that any ſingle earth cannot conſtitute manure to be applied in all caſes; but the character of the ſoil intended to be meliorated, ought firſt to be examined and conſidered before any deciſion is made concerning the manure to be applied. M. Tillet has aſcertained, that the beſt proportions of a fertile earth for corn, are three-eighths clay, two-eighths ſand, and three-eighths fragments of hard ſtone.

The advantage of labour or cultivation conſiſts in dividing the earth, impregnating it with air, deſtroying uſeleſs and noxious plants, and converting them into manure by facilitating their decompoſition. *See* ARABLE LAND.

EARTH, VITRIFIABLE. Every earth is in fact vitrifiable with proper additions, and none without, except the new fuſible earth. But ſiliceous earth has been rather generally diſtinguiſhed by this name, on account of the ſuperior facility with which it is converted into a good glaſs by fuſion with an alkali. *See* EARTH SILICEOUS, *alſo* GLASS.

EARTH WORMS are plentifully found in moiſt fat grounds, but rarely, if ever, in dry ſands. M. Reaumur propoſed collecting them as a cheap ſubſtitute for grain in feeding domeſtic poultry. The phyſicians, who appear to have overlooked ſcarcely any produce of the three kingdoms of nature, have uſed theſe creatures, under the notion of their poſſeſſing an antiſpaſmodic and diuretic virtue. Neumann relates ſeveral experiments made with them. They are cleanſed by waſhing, and ſuffering them to creep through dry woollen cloths. Unleſs haſtily dried by the heat of the ſun or a fire, they are very apt to putrefy. Moiſtened with wine or vinous ſpirit, to prevent their putrefaction, and ſet in a cellar in a wide-mouthed glaſs, they are almoſt wholly reſolved in a few days into a ſlimy liquor. When this liquamen or ſolution is mixed with a little fixed alkali, and after due evaporation ſet by to ſhoot, the cryſtals are no other than ſaltpetre. Neumann did not in direct terms aſſert that he himſelf made this experiment, and from the context there ſeems to be ſome ſlight reaſon to ſuſpect he had it from Stahl.

He made however his uſual ſet of experiments with them by digeſtion in water and ardent ſpirit, and by deſtructive diſtillation. When repeated digeſtion with the ſpirit was uſed firſt, the quantity of extract from four ounces of the dried worms, and the reſiduum treated with water, yielded three drams and a ſcruple. But the ſame quantity treated firſt with water, afforded one ounce, ſix drams, and a ſcruple, after which rectified ſpirit extracted two ſcruples.

Thirty-two ounces of dried earth-worms yielded, by deſtructive diſtillation, thirteen ounces and a half of an alkaline fluid, one ounce of concrete volatile alkali,

alkali, and four ounces and a half of empyreumatic oil. The remainder burned in the open air afforded, by lixiviation, one ounce and a half of fixed alkali. The earthy reſiduum weighed ſix ounces and a half, which, at that early period of chemiſtry, Neumann did not poſſeſs the methods of examining. If the worms were putrefied by diſtillation, the volatile product was ſcarcely any thing but mere water, with very little oil and volatile alkali.

EAU DE LUCE. The ſmell of the volatile alkali is rendered conſiderably more grateful by an imperfect combination with oil. Eau de luce is a compound of this nature, conſiſting chiefly of the eſſential oil of amber and the volatile alkali. There is ſome difficulty in compounding this fluid, ſo that it ſhall poſſeſs the deſired quality of a beautiful milky whiteneſs. For if the combination be too perfect by a due proportion of the materials, it will approach to tranſparency; and if it be leſs perfect by a redundancy of oil, this laſt will ſeparate in the form of globules, or in a kind of cream. Macquer * ſpeaks highly of the following receipt, taken from the French edition of the London Diſpenſatory.

Take four ounces of rectified ſpirit of wine, and in it diſſolve ten or twelve grains of white ſoap; filter the ſolution, then diſſolve in it a dram of rectified oil of amber, and filter again. Mix as much of this ſolution with the ſtrongeſt ſpirit of ſal ammoniac or pure volatile alkali, in a flint glaſs bottle, as, when ſufficiently ſhaken, ſhall produce a beautiful milky fluid. If a cream be formed on its ſurface, ſome more of the oily ſpirit of wine muſt be added.

ECHINI. Calcareous petrifactions of the echinus, or ſea hedgehog.

EDULCORATION. This word imports the ſame thing as dulcification, properly ſpeaking; namely, the rendering things more mild: but chemiſts uſe the terms very differently. Dulcification conſiſts in the obtunding of acids by combination with ardent ſpirit (ſee the word). Edulcoration conſiſts in carrying off ſuperfluous acid, or other ſaline matter, by one or more waſhings with water. Metallic calces and other inſoluble precipitates are uſually edulcorated previous to drying them.

EFFERVESCENCE. According to its derivation, this term implies the boiling over of any fluid by heat. In chemiſtry it is appropriated to the commotion and increaſe of volume produced in fluids by ſome part of the maſs ſuddenly taking the elaſtic form, and eſcaping in numerous bubbles. Thus, when an acid is poured on chalk, the fixed air is diſengaged in the elaſtic ſtate with bubbles, vapour, and an hiſſing noiſe.

Effervеſcences are more or leſs violent, according to circumſtances, and are uſually attended with a change of the temperature. If the capacity of the mixture or new combination for heat be diminiſhed by the change the bodies have undergone, in a greater degree than that of the elaſtic fluid is enlarged, the temperature will be increaſed: but if, on the contrary, the mixture retain its original or acquire an increaſed capacity, the elaſtic fluid will carry off ſo much of the heat as to produce a greater or leſs degree of cold in the remainder. Chemiſtry affords many inſtances of both effects taking place.

EFFLORESCENCE is the effect which takes place when ſolid or conſiſtent bodies gradually and ſpontaneouſly become converted into a powder. It is almoſt always occaſioned by the loſs of the water of cryſtallization in ſaline bo-

* Chemical Dictionary, art. Eau de Luce.

dies. Thus the mild mineral alkali, Glauber's ſalt, martial vitriol, and many other ſalts, are efflorescent; that is, they become dry and pulverulent, when left expoſed to the air. Other efflorescences are occaſioned not ſimply by the loſs of moiſture, but by proceſſes of a more compounded nature, ſuch as the efflorescence of vitriolated clay or alum-ſlate by the converſion of its ſulphur into vitriolic acid, by roaſting and expoſure to the air, or the efflorescence of the martial pyrites, which by the ſame treatment become converted into green vitriol, though originally compoſed of ſulphur and iron.

EGGS. The eggs of hens and of birds in general are compoſed of ſeveral diſtinct ſubſtances. 1. The ſhell or external coating, which is compoſed of lime and phoſphoric acid, and conſequently of the ſame nature as bones, though its thinneſs and extreme poroſity render it apparently more brittle. 2. A thin white and ſtrong membrane, poſſeſſing the uſual characters of animal ſubſtances. 3. The white of the egg, which is an adheſive, tranſparent, and imperfectly fluid ſubſtance, becoming opake and hard by a degree of heat which does not deprive it of any weight, diffuſible in water, and ſeparable by the ſame coagulating mediums as ſeparate the curd of milk, from which, according to Scheele, it does not at all differ. *See* CHEESE. Both theſe ſubſtances poſſeſs the quality of ſerum, which is diffuſible in cold water, and coagulates by heat, and accordingly the refiners of ſugar and other manufacturers uſe either eggs or blood almoſt indiſcriminately in clarifying their ſolutions. For the white of egg, when it aſſumes the ſolid form, riſes to the top, in the form of ſkum, carrying the groſs impurities along with it, probably by a mere mechanical colation or ſtraining. 4. The yolk, which appears to conſiſt of an oil of the nature of fat oils, united with a portion of ſerous matter, ſufficient to render it diffuſible in cold water, in the form of an emulſion, and concreſcible by heat. Yolk of egg is uſed as the medium for rendering reſins and oils diffuſible in water. An oil of eggs is procured by expreſſion from the yolks of eggs, previouſly roaſted to deprive the ſerous part of its fluidity. A ſlight empyreuma is given to the oil by this treatment, which might probably be avoided by applying no greater heat than on trial might be found ſufficient to coagulate the ſerum.

The products afforded by the ſeveral parts of eggs, ſubjected to deſtructive diſtillation, are nearly the ſame as are obtained by that method from other animal matters.

Mr. Reaumur found that eggs might be preſerved during months or years, by being covered with mutton ſuet, or any other fat ſubſtance.

ELECAMPANE. Neumann diſtilled thirty-two ounces of the root, and obtained three ſcruples and a half of oil, part of which ſtuck in the head of the ſtill, and part paſſed down into the receiver, along with the water made uſe of. He did not obtain a concrete of this nature from any other vegetable. It reſembles camphor in ſome reſpects, but not in all. Water does not affect it. Ardent ſpirit totally diſſolves it. When laid on burning coals, it exhales without leaving any reſidue. Held over a gentle fire in a ladle, it flows like wax or tallow, and when cold, appears ſofter and more unctuous than at firſt. The younger Geoffroy obſerves that this matter reſides in the exterior parts of the root near the bark.

Rectified ſpirit diſtilled from the root carries nothing over, and water leaves more behind it than it takes up. One ounce of the dry root afforded ſix drams and a half of extract with water; but the ſame quantity with ſpirit gave only two drams and a half with ſpirit.

ELECTRUM. Amber. See the article.

ELEMENTS. A term uſed by the earlier chemiſts, nearly in the ſame ſenſe as the moderns uſe the terms firſt principle. The chief, and indeed very eſſential difference between them is, that the ancients conſidered their elements as bodies poſſeſſing abſolute ſimplicity, and capable of forming all other bodies by their mutual combination; whereas the firſt principles of the moderns are conſidered as ſimple, merely in reſpect to the preſent ſtate of the art of analyſing bodies. That is to ſay, the ancients almoſt totally overlooked the imperfection of the art in their general deductions; but the moderns pretend to keep it in view.

The experiments made in the infancy of chemiſtry had for their object, the phenomenon of combuſtion, referred by them to a ſubſtance called fire; the extrication of elaſtic fluid, conſidered to be of the ſame nature as the immenſe maſs which compoſes the atmoſphere; water, neither compoundable nor deſtructible by any experiments then known or underſtood; and ſubſtances not volatile in the ſtrongeſt heat of furnaces, confounded by them, with a few exceptions, under the general term of earth. In this way they obtained four elements or firſt principles, fire, air, water, and earth.

Subſequent experiments and enquiries have multiplied the number of elements, and have alternately ſhewn the inutility of any excluſive general arrangement of bodies, as abſolutely ſimple, becauſe not yet analyſed. *See* PRINCIPLES; *alſo* ATTRACTION.

ELIQUATION. An operation, by means of which a more fuſible ſubſtance is ſeparated from another which is leſs fuſible. It conſiſts in the application of a degree of heat ſufficient to fuſe the former, but not the latter. It may be effected either by uſing a perforated crucible, or in the large way, by a furnace conſtructed to anſwer the ſame purpoſe. In order that a ſeparation may follow by this method, it is neceſſary that the combination between the two ſubſtances ſhould be by no means intimate. Thus ſulphur may be ſeparated from its earthy admixtures by the gentle heat neceſſary to fuſe it; but it cannot, in the ſame manner, be ſeparated from its metallic combinations. So likewiſe lead may be ſeparated by eliquation from copper; but tin cannot.

ELUTRIATION. This word is uſed by chemiſts to denote the proceſs of waſhing, as practiſed by metallurgiſts and others; and indeed this laſt and more familiar term is moſt frequently uſed. Thus the metallic ores are cleared of earthy admixtures by elutriation, that is to ſay, waſhing with water, which carries off the lighter earthy parts, while the heavier metallic parts ſubſide to the bottom.

EMERALD. A tranſparent precious ſtone, of a green colour, nearly of the ſame hardneſs as the garnet, or agate; but inferior to the topaz and ruby. In its rough, or native ſtate, it conſiſts of ſix-ſided priſms, commonly truncated at both ends. Engeſtrom ſays, that they become of an opake white in a ſtrong fire, without the leaſt mark of fuſion: but Wallerius aſſerts, that this ſtone, when heated to a white heat, becomes of a deep blue colour, and phoſphoreſcent, and recovers its green colour when cold. From theſe facts it ſeems probable, that the experiments of theſe two naturaliſts were made with different kinds of emeralds; or elſe, that the white colour in the former experiments might ariſe from an infinity of flaws produced by the ſudden application of heat. Friction produces electricity in the emerald. Some emeralds, of the dark green ſort, reſemble the

tourmalin in the property of attracting ſmall bodies, by an electricity produced by heating and cooling.

When cryſtallized cockle, or ſhirl, is found of a green colour, tranſparent, and free from cracks or flaws, it is commonly called emerald by the jewellers, though it is generally of a deeper colour than the true emerald, and alſo wants their luſtre; and hence it is, that the cockle ſpar from Egypt is called the mother of emeralds. However, it is probable that this cockle was, in ancient times, faſhionable in Egypt, under the name of emerald, though at preſent it is not ſo much valued as the emerald of this (ſiliceous) kind.

The true emerald is not acted upon by mineral alkali in the dry way, but it yields to borax and microcoſmic ſalt, with which, according to Quiſt and Wallerius, it affords a colourleſs glaſs.

According to Bergman's analyſis, 100 parts of this ſtone contain 60 of clay, 24 of ſilex, 8 of lime, and 6 of iron. By Mr. Achard's analyſis, the component parts were nearly the ſame.

EMERY. I do not know of any analyſis of this ſubſtance. The beſt ſort is of a dark grey colour, but becomes brown, and in a great meaſure magnetical, by calcination. Other ſorts are of a reddiſh ruſty white or yellowiſh colour. This mineral ſcarcely yields to any ſubſtance in hardneſs, excepting the diamond. It is much uſed for grinding and poliſhing. Mr. Kirwan thinks that it conſiſts of a mixture of the red and white calces of iron with ſome unknown ſtony ſubſtance, perhaps tripoli.

EMPYREUMA. This term is applied to denote the peculiar ſmell produced by a conſiderable heat upon vegetable or animal ſubſtances, in cloſed veſſels, or when burned under circumſtances which prevent the acceſs of air to a conſiderable part of the maſs, and conſequently occaſion an imperfect combuſtion, or deſtructive diſtillation of the parts ſo covered up by the reſt of the maſs.

Mr. Macquer obſerves, that empyreuma is the peculiar ſmell of burned oils, and that no other but oily ſubſtances can produce it. He even propoſes this indication as a teſt of the preſence of oil, in bodies which contain too ſmall a quantity of that fluid to admit of any other way of exhibiting it.

EMULSION. An imperfect combination of oil and water, by the intervention of ſome other ſubſtance, capable of combining with both theſe ſubſtances. The ſubſtances are either ſaline or mucilaginous. Thus the volatile alkali with certain management forms the emulſive liquor called volatile liniment and eau de luce. Gum arabic, or ſugar triturated with oils, renders them miſcible with water, as do likewiſe white of egg and other animal mucilages. The vegetable juices obtained by compreſſion from various ſeeds and other parts of vegetables, are of an emulſive nature. But it does not ſeem probable that they exiſt in the vegetable under the emulſive form, but rather that the ſeveral diſtinct veſſels reſpectively contain oil, water, mucilage, or ſugar, the confuſed mixture of which produces the emulſion. On the ſame principle it ſeems to be, that the gum reſins afford emulſions when triturated with water.

Sir Iſaac Newton has ſhewn by experiment that all bodies are tranſparent, whoſe particles do not exceed a certain magnitude, which he has deduced by computation in his Optics. When opacity is the reſult of a combination of two tranſparent bodies, it affords a conſiderable proof, that their union is little more than mechanical. It is well known how ſlowly ſmall particles either ſink or ariſe to the ſurface of any fluid in which they may be ſuſpended. Atwood, in his

Treatiſe on the rectilinear and rotatory Motion of Bodies, and other writers, have ſhewn the methods of aſcertaining theſe velocities, when the denſities of the particles and of the fluid, together with the magnitude of the former, are known. Whence it is not to be wondered, that a ſlight tendency to chemical combination, aſſiſted by minute mechanical diviſion, ſhould occaſion the reſpective parts of emulſive liquors to remain for a long time without ſeparation. It is found, however, that in proceſs of time they do ſeparate.

ENAMELLING. The art of enamelling on metals is treated at full length by Mr. Brougniart, in the 9th volume of the Annales de Chimie, from whom I ſhall take the greateſt part of this article.

Neri on Glaſs, with the notes of Merret and Kunckel, afford a variety of good receipts for making enamels, though much ſtill remains to be done in this art. The art is indeed retarded by the conſiderable advantage the enameller derives from a diſcovery of any colour uncommonly brilliant, clear, or hard. On this account the artiſt naturally endeavours to keep his proceſs a ſecret, as the ſource of private gain. The principal ingredients of enamel colours are, however, well known.

There are two kinds of enamel, the opake and the tranſparent. Tranſparent enamels are uſually rendered opake by adding putty, or the white calx of tin, to them. The baſis of all enamels is therefore a perfectly tranſparent and fuſible glaſs. The calx of tin renders this of a beautiful white, the perfection of which is greater when a ſmall quantity of manganeſe is likewiſe added. If the calx of tin be not ſufficient to deſtroy the tranſparency of the mixture, it produces a ſemi-opake glaſs, reſembling the opal.

Yellow enamel is formed by the addition of calx of lead, or antimony. Kunckel likewiſe affirms, that a beautiful yellow may be obtained from ſilver.

Red enamel is afforded by the calx of gold, and alſo by that of iron. The former is the moſt beautiful, and ſtands the fire very well, which the latter does not.

Calx of copper affords a green; manganeſe, a violet; cobalt, a blue; and iron, a very fine black. A mixture of theſe different enamels produces a great variety of intermediate colours, according to their nature and proportion. In this branch of the art, the coloured enamels are ſometimes mixed with each other, and ſometimes the calces are mixed before they are added to the vitreous baſes.

The enameller, who is provided with a ſet of good colours, is very far from being in a ſituation for practiſing the art, unleſs he be ſkilled in the methods of applying them, and the nature of the grounds upon which they are to be laid. Many of the metals are too fuſible to be enamelled, and almoſt all of them are corroded by the action of the fuſed glaſs. For this reaſon, none of the metals are uſed but gold, ſilver, and copper. Platina has indeed been uſed; but of its effects and habitudes with enamels, very little can be ſaid, for want of a ſufficient number of experiments.

The pureſt gold of 24 carats is calculated to produce the beſt effect with enamel. 1. Becauſe it entirely preſerves the metallic brilliancy without undergoing any calcination in the fire. 2. Being leſs fuſible, it would admit of a more refractory, and conſequently a harder and more beautiful enamel. It is not uſual, however, to enamel upon finer gold than 22 carats; and the operation would be very defective, if a coarſer kind than that of 18 carats were uſed. For in this caſe more alkali muſt be added to the enamel, to render it more fuſible, and this addition would at the ſame time render it ſofter and leſs brilliant.

Rejecting

Rejecting all theſe exceptions, the author gives the following deſcription, by way of example, of fixing a tranſparent blue enamel upon gold of 22 carats.

The artiſt begins his operation by breaking the enamel into ſmall pieces in a ſteel mortar, and afterwards pulveriſing it in a mortar of agate. He is careful to add water in this part of his proceſs, which prevents the ſplinters of glaſs from flying about. There are no means of explaining the point at which the trituration ought to be given up, as this can be learned only by experience. Some enamels require to be very finely triturated; but others may be uſed in the form of a coarſe powder. As ſoon as he apprehends that his enamel is ſufficiently pounded, he waſhes it by agitation in very clear water, and pouring off the fluid as it becomes turbid. This operation, which is made for the purpoſe of carrying off duſt and every other impurity from the enamel, is continued until the water comes off as clear as it was poured on.

The workman puts his enamel, thus prepared, in a white china or earthen ſaucer, with water poured on it to the depth of about one tenth of an inch. He afterwards takes up this enamel with an iron ſpatula, as equally as poſſible. As the enamel here ſpoken of is tranſparent, it is uſual to ornament the ſurface of the gold with roſe work, or other kinds of work, calculated to produce a good effect through the enamel.

The thickneſs of this firſt layer depends entirely upon its colour: delicate colours, in general, require that it ſhould have no great thickneſs.

The moiſt enamel being thus placed, is dried by applying a very clean half-worn linen cloth to it, which muſt be very carefully done, to avoid removing the enamel by any action of wiping.

In this ſtate the piece is ready for the fire. If it be enamelled on both ſides, it is placed upon a tile, hollowed out in ſuch a manner, that the uncovered edges of the piece alone are in contact with the iron. But if it be enamelled on one ſide only, it is ſimply laid upon the plate, or on a tile. Two things, however, require to be attended to. 1. If the work be very ſmall, or not capable of being enamelled on its oppoſite ſide, the iron plate muſt be perfectly flat, in order that the work may not bend when ſoftened by heat. 2. If the work be of conſiderable ſize, it is always counter-enamelled if poſſible; that is to ſay, an enamel is applied on the back ſurface, in order to counteract the effect which the other coating of glaſs might produce on the ſoft metal, when it came to contract by cooling.

The enamellers furnace is ſquare and built of bricks, bedded in an earth proper for the purpoſe. It may be conſidered as conſiſting of two parts, the lower part, which receives a muffel, reſting on the floor of the furnace, and open on both ſides.

The upper part of the furnace conſiſts of a fire-place, rather larger and longer than the dimenſions of the muffel. This fire-place contains the charcoal, which muſt ſurround the muffel on all ſides, excepting at the bottom. The charcoal is put in at a door above the muffel, and which is cloſed when the fire is lighted. A chimney proceeds from the ſummit of the furnace with a moderate aperture, which may be cloſed at the pleaſure of the artiſt, by applying a caſt iron plate to it. This furnace differs from that of the aſſayer in the circumſtance that it is ſupplied with air through the muffel itſelf: for if the draught were beneath the muffel, the heat would be too ſtrong, and could not be ſtopped when requiſite.

As

As ſoon as the fire is lighted, and the muffel has obtained the requiſite degree of ignition, the charcoal is diſpoſed towards the lower part of the muffel in ſuch a manner as that it ſhall not fall upon the work, which is then conveyed into the muffel with the greateſt care upon the plate of iron or earthen ware, which is taken up by long ſpring pinchers. The work is placed as near as poſſible at the further extremity of the muffel; and as ſoon as the artiſt perceives a commencement of fuſion, he turns it round with great delicacy, in order that the fuſion may be very uniform. And as ſoon as he perceives that the fuſion has completely taken place, he inſtantly removes it out of the furnace: for the fuſion of gold happens ſo very near that of the enamel, that a neglect of a few ſeconds might be attended with conſiderable loſs.

When the work is cooled, a ſecond coat of enamel is applied in the ſame manner as the firſt, if neceſſary. This, and the ſame cautious management of the fire, are to be repeated for every additional coat of enamel the nature of the work may demand.

As ſoon as the number of coatings are ſufficient, it becomes neceſſary to give an even ſurface to the enamel, which, though poliſhed by the fire, is nevertheleſs irregular. This is done with an Engliſh fine-grained file and water. As the file wears ſmooth, ſand is uſed. Much precaution and addreſs are required in this part of the work, not only becauſe it is eaſy to make the enamel ſeparate in ſplinters from the metal, but likewiſe becauſe the colour would not be uniform if it were to be ground thinner at one part than at another.

The deep ſcratches of the file are in the next place taken out, by rubbing the ſurface with a piece of deal wood and fine ſand and water. A poliſh is then given by a ſecond ignition. This poliſh, however, is frequently inſufficient, and not ſo perfectly uniform as the delicacy of the work may require.

The ſubſtance uſed by the enamellers, as a poliſhing material, is known by the name of rotten-ſtone; which is prepared by pounding, waſhing, decanting off the turbid water, ſuffering the fine ſuſpended particles to ſubſide from this water, and laſtly levigating it upon a glaſs plate.

The work is then cemented to a ſquare piece of wood with a mixture of roſin and brick-duſt, and by this means fixed in a vice.

The firſt operation of poliſhing is made by rubbing the work with rotten-ſtone upon a ſmall ſtrait bar of pewter. Some delicacy is here required, to avoid ſcratching or producing flaws in the enamel, by preſſing it too hard. In this way the piece is rendered perfectly even: but the laſt brilliant poliſh is given by a piece of deal wood and the ſame rotten-ſtone.

This is the general method of applying enamels; but ſome colours require more precaution in the management of the fire. Opake colours require leſs management than the tranſparent. A variety of circumſtances muſt be attended to in the management of tranſparent colours; every colour requires gold of a particular fineneſs.

When different colours are intended to be placed beſide one another, they are kept ſeparate by a ſmall edge or prominency, which is left in the gold for that purpoſe, and is poliſhed along with the enamel.

The enamelling upon ſilver is effected nearly in the ſame manner as that of gold; but the changes ſuſtained by the colours upon the ſilver, by the action of fire, are much more conſiderable than when gold is uſed.

Copper

Copper is not much uſed by enamellers, on account of the difficulty which attends the attempt to fix beautiful colours upon it. When this metal is uſed, the common practice is to apply a coating of opake white enamel, and upon this other colours which are more fuſible than the white.

A good effect is produced in toys, by leaving part of the gold bare. For this purpoſe its ſurface is cut into ſuitable compartments by the engraver. This, however, is an expenſive method, and is for that reaſon occaſionally imitated by applying ſmall and very thin pieces of gold upon the ſurface of the enamel, where they are fixed by the fire, and afterwards covered by a tranſparent vitreous coating.

After this detail of the art of enamelling, Mr. Brougniart deſcribes a method of taking off the enamel from any toy, without injuring its metallic part. For this purpoſe, a mixture of common ſalt, nitre and alum in powder, is applied upon the enamel, and the piece put into the furnace. As ſoon as the fuſion has taken place, the piece is ſuddenly thrown into water, which cauſes the enamel to fly off either totally or in part. The part which may remain is to be removed by repeating the ſame operation a ſecond time. *See* GLASS; *alſo* POTTERY.

ENS MARTIS. A name anciently given to the calx of iron which ariſes in ſublimation, with twice its quantity of ſal ammoniac. Medical practice does not at preſent place this preparation in a higher rank of eſtimation than other calces of iron.

ENS VENERIS. The ens martis is in many diſpenſatories called by this name; others direct a ſublimation to be made with ſal ammoniac, and the calx of cupreous vitriol, a proceſs which it is well known affords no flowers, or at leaſt a quantity proportioned merely to the iron with which the vitriol of copper may be contaminated. It appears, therefore, that there is no ens veneris.

ENTROCHI. A genus of extraneous foſſils, uſually of about an inch in length, and made up of a number of round joints, which, when ſeparate and looſe, are called trochitæ: they are compoſed of the ſame kind of plated ſpar with the foſſil ſhells of the echini, which is uſually of a blueiſh grey colour; and are very bright where freſh broken: they are all ſtriated from the centre to the circumference, and have a cavity in the middle. They ſeem to be the petrified arms of that ſingular ſpecies of the ſea ſtar-fiſh, called Stella Arboreſcens.

ESSAY. *See* ASSAY.

ESSENCES. Several of the volatile or eſſential oils are called eſſences by the perfumers.

ETHER. A very volatile fluid, produced by the diſtillation of ardent ſpirit with an acid. The vitriolic ether is upon the whole beſt known, though there are various ethers made by means of other acids. As ſome advantages may be gained by treating of the whole under one article, I ſhall accordingly purſue that method.

Various paſſages in the writings of the earlier chemiſts ſufficiently evince, that the vitriolic ether was among their ſecrets; but it was ſcarcely attended to before the year 1730, when a certain quantity was preſented to the Royal Society by Dr. Frobenius, and certain experiments were made of its moſt obvious qualities.

When ſtrong vitriolic acid is poured upon an equal meaſure of rectified ſpirit of wine, the fluids unite with an hiſſing noiſe and the production of heat, at the ſame time that a fragrant vegetable ſmell is perceived, reſembling that of apples. It is much better and ſafer, however, to add the acid by ſmall portions at a time,

at

at ſuch intervals of time, as that no perceptible heat may be produced. The mixture may be made in a glaſs retort, and the diſtillation performed by regulated heat on a ſand-bath, a large receiver being previouſly well adapted and kept cool by immerſion in water, or the frequent application of wet cloths. The compound apparatus, fig. 2. plate I. may be advantageouſly uſed in this as in other diſtillations. The firſt product is a fragrant ſpirit of wine, which is followed by the ether, as ſoon as the fluid in the retort begins to boil. At this period the upper part of the receiver is covered with large diſtinct ſtreams of the fluid, which run down its ſides. After the ether has paſſed over, volatile ſulphureous acid ariſes, which is known by its white fumes and peculiar ſmell. At this period the receiver muſt be unluted and removed, care being taken to avoid breathing the penetrating fumes of the acid; and the fire muſt at the ſame time be moderated, becauſe the reſidue in the retort is diſpoſed to ſwell. A light yellow oil, called ſweet oil of wine, comes over after the ether, and is ſucceeded by black and foul vitriolic acid. The reſidue varies in its properties according to the management of the heat. If the fire be much increaſed towards the end of the proceſs, the volatile vitriolic acid that comes over will be mixed with vinegar. If the remaining fluid contained in the retort after the ether has paſſed over, be not urged further, it may be made to afford more ether by the addition of one-third of very ſtrong ſpirit; and this may be repeated ſucceſſively, with leſs quantities, until near twice the quantity of the ſpirit originally made uſe of has been added.

The ether comes over mixed with ſpirit of wine and ſome volatile vitriolic acid. It was uſual to add ſome diſtilled water to this product, which occaſioned the ether to riſe to the top. Rectification is abſolutely neceſſary if the ether have a ſulphureous ſmell; and this is indeed the better method in all caſes, becauſe the water added in the old method always abſorbs about one-tenth part of its weight of ether, which cannot be recovered without having recourſe to diſtillation; and alſo, becauſe the ether is found to abſorb a quantity of the water. Simple rectification, with the addition of a little lime or alkali, and by a gentle heat, is therefore preferable.

Dr. Hopſon, in his General Syſtem of Chemiſtry, taken chiefly from Weigleb *, has given a very copious abſtract of the experiments on ethers of M. Dollfuſs, related by him in his Pharmaceutiſch-Chemiſche Erfahrungen ed Leipzig, 1787, which well deſerves to be conſulted, and to which the reader is referred for fuller information on this ſubject. The inexperienced chemiſt muſt, however, be reminded, that the extreme inflammability of ardent ſpirit, and ſtill more of ether; the danger of exploſion which attends the ſudden mixture and agitation of concentrated acids and ardent ſpirit; and the ſuffocating effect of the elaſtic fluids, which might fill the apartment if inadvertently diſengaged; are all circumſtances which require cautious management.

Vitriolic ether is one of the lighteſt and moſt volatile of all non-elaſtic fluids. Its diſſipation into the air by evaporation is ſo ſudden as to produce extreme cold. It is highly inflammable, burns with a more luminous flame than ardent ſpirit, and emits more ſmoke.

The action of this fluid upon ſaline ſubſtances has been little attended to. It does not appear to act upon lime or fixed alkalis. Cauſtic volatile alkali com-

* Page 511.

bines with it in all proportions. Vitriolic acid combines with it, and extricates heat; and from this compound the ſweet oil of wine may be obtained by diſtillation. Nitrous acid cauſes an efferveſcence, and renders it more oily. It diſſolves camphor very plentifully.

Nitrous acid has ſo ſtrong a diſpoſition to combine with ardent ſpirit, that a conſiderable danger of exploſion attends the mixture of theſe fluids. Both theſe circumſtances have given riſe to a number of proceſſes for forming nitrous ether. It has been made by mixing the two fluids in a retort, connected with very capacious receivers; a method in which it is probable, that no ordinary degree of precaution would be ſufficient to ſecure the operator from the danger of the veſſel's being blown in pieces by the elaſtic fluid that is ſo ſuddenly extricated. It may alſo be obtained without diſtillation, from a mixture of nitrous acid and ardent ſpirit. For this purpoſe, ſix ounces of highly rectified ſpirit of wine are put into a ſtrong bottle, capable of containing one pound of water, and immerſed up to the neck in a veſſel of very cold water, in which it will be advantageous to put three or four pounds of ice, broken ſmall. Upon the ſpirit, in this ſituation, and kept continually agitated, four ounces of nitrous acid of the ſpecific gravity of 1.5, are to be poured, in four or five ſucceſſive portions, or even more gradually. As ſoon as the mixture is completed, the bottle muſt be cloſed with a good cork, ſecured with leather and packthread, or wire; and the whole muſt be left in a place where it may remain undiſturbed, no other attention being neceſſary than that of renewing the water from time to time, as it may become heated. In the courſe of two or three hours the tranſparency of the fluid becomes troubled by an infinity of drops of ether, which are diſengaged from every part of its volume. This ether gradually riſes to the ſurface, and at the end of twenty-four hours it may be ſeparated from the reſt of the liquor by means of a funnel. In opening the phial, it is neceſſary firſt to pierce the cork with a pointed inſtrument, in order that a quantity of elaſtic fluid may eſcape, which might otherwiſe ſuddenly follow the cork, and carry part of the fluid along with it. The quantity of ether obtained in this way will be about four ounces. Its colour is of a light orange, and part is diſpoſed to eſcape with efferveſcence, whenever the bottle which contains it is unſtopped. This ſeems to ariſe from a portion of uncombined acid contained in the fluid. It muſt be rectified in order to have it pure; and in this proceſs it loſes near half its weight.

The danger attending the making of nitrous ether is leſs when the acid is diluted. The method of Dr. Dehne, as deſcribed by Weigleb *, though he uſes concentrated acid, appears to be very ſafe. This chemiſt put two pounds of pure ardent ſpirit into a tubulated retort, to which a large receiver was luted, and added to this half an ounce of fuming nitrous acid every four hours, drop by drop. Twelve ounces of the acid having been introduced in this manner into the retort, and half an ounce more being added, the mixture began to throw up ſmall bubbles, though without producing any heat, and twelve hours elapſed before all was quiet again. By this means about an ounce of ether came over into the receiver, which, on the farther addition of nitrous acid, received an increaſe. After this, two drams of the acid only were added morning and evening. On the eighth day, after the firſt addition, a greeniſh ether was ſeen to cover the liquor in the retort, to the depth of about half an inch; but the addition of

* General Syſtem of Chemiſtry, by Hopſon, page 514.

nitrous

nitrous acid was ſtill continued, till on the twelfth day one pound and five ounces of nitrous acid had been introduced into the receiver. The mixture then began to be affected with a briſker motion, when the ether was taken off, and weighed one pound and one ounce. Upon the reſiduum he then poured, drop by drop, as before, two drams of nitrous acid morning and evening, till the acid fell to the bottom in the form of perfectly green globules. Dr. Dehne, in conſequence of much experience, affirms, that theſe bubbles are a ſign that no more ether will be ſeparated by any ſubſequent addition of nitrous acid; but that the mixture is ſaturated with nitrous acid, and will yield no further produce, unleſs ardent ſpirit be added. The quantity of ether ſeparated the ſecond time, amounted to eight ounces and three drams. So that the whole produce of ether was one pound, nine ounces, and three drams, afforded by adding one pound, ten ounces, and three drams of nitrous acid to two pounds of ardent ſpirit. The reſiduum weighed one pound twelve ounces, and five ounces were loſt, which was probably ether. The operation ſucceeds beſt in cold weather; and it has frequently been obſerved, that ardent ſpirit, diſtilled from oily bodies, yields more ether than when pure. This nitrous ether, like the foregoing, is commonly ſtill acid, and may be treated with a ſolution of alkali, and ſubſequent rectification.

We ſhall barely mention the other leſs direct proceſſes for forming nitrous ether: 1. A mixture, of two parts vitriolic acid and four ardent ſpirit, added to four parts dry nitre, affords by diſtillation a dulcified nitrous acid, mixed with ether, of which two parts may be had by rectification *. 2. If nearly one part of diluted nitrous acid be carefully poured upon two parts of denſe nitrous acid; and upon this there be poured, with the ſame caution, three parts of ſtrong ardent ſpirit; and this compound fluid be left to ſtand in a phial looſely corked, the acid and ſpirit will gradually act upon each other, and ether will in a day or two be formed at the top. The whole being put into a retort, affords two parts and more of very pure ether, by diſtillation. 3. If nitrous acid be diſengaged in the uſual way from nitre by the addition of vitriolic acid, and the acid which comes over be received into ardent ſpirit, this laſt will become in part converted into ether, which may be ſeparated by rectifying. The method is ſaid to be attended with ſome danger.

In certain proportions of the materials, and by due management of the proceſs for making nitrous ether, the nitrous acid wholly diſappears, and the reſidue is found to contain no nitrous acid, but ſome vinegar and the acid of ſugar.

Rectified nitrous ether burns with a flame rather more luminous than that afforded by the vitriolic ether, at the ſame time that it gives out rather more ſmoke, and leaves a black trace behind. In other reſpects it very much reſembles the vitriolic ether.

The methods of making marine ether conſiſt in applying the marine acid, in the dephlogiſticated or aërated ſtate, to ardent ſpirit; for, in the common ſtate of the acid, their mutual action is little or none. In Mr. Weſtrumb's method, it is procured from four ounces of common ſalt, two of powdered manganeſe, two of vitriolic acid, and ſix of ardent ſpirit, by means of diſtillation. The liquor being diſtilled to dryneſs, is poured back upon the reſiduum, and diſtilled afreſh. In this diſtillation, nearly the half which comes over is dulcified marine acid, and moſt of the other half marine ether, which may be ſeparated from the reſt by the addition of water.

* Dollfuſs.

Marine ether is very tranſparent and volatile, and burns with a ſmoke and ſuffocating ſmell. Many chemiſts doubt the exiſtence of marine ether, and aſſert, that the product which is ſo called is merely a dulcified ſpirit.

It is a queſtion whether any ether can be produced by the direct application of the acetous acid to ardent ſpirit. It appears to be a condition, that the acid ſhould be in the aërated ſtate; and as it appears to exiſt in this ſtate (uſually called radical vinegar), in moſt ſalts the ethereal combinations are beſt effected in the indirect methods. According to Weſtendorf's recipe, equal parts of the ſtrongeſt ſpirit of vinegar (probably the radical vinegar) and ardent ſpirit are mixed together, and ſuffered to ſtand for ſome days in a well-ſtopped glaſs veſſel, until the mixture has acquired a peculiarly agreeable ſmell. The liquor is then to be poured into a retort with a receiver accurately luted on, and nearly the half is to be drawn off by a gentle heat. One ſixteenth part of fixed alkali, diſſolved in four times its weight of water, is to be added to the diſtilled product, and the fluid gently agitated with a circular motion, which will cauſe the ether to riſe and float at the ſurface like oil, whence it may be taken off. Its quantity commonly amounts to half that of the ardent ſpirit employed. Half the original quantity of ardent ſpirit may be again added to the acetous reſidue once or twice more, by which means the ethereal product will be ſtill more augmented.

Various methods are given of producing acetous ether by the decompoſition of an acetous neutral ſalt, by the addition of a mineral acid. Thus, if an ounce of alkali ſaturated with vinegar be diſſolved in three ounces of ardent ſpirit, and a little more of any mineral acid be added than is requiſite to ſaturate the alkali, and the maſs be then diſtilled, acetous ether will be obtained. Or if eight ounces of ſugar of lead be gently dried to deprive it of its water of cryſtallization, which amounts to rather more than one fourth of its weight; if in this ſtate it be put into a glaſs retort, and a mixture of five ounces of vitriolic acid, and eight ounces of ſpirit of wine, be poured on it, and the whole be expoſed to diſtillation by a very gentle heat; the firſt ounce that paſſes over will conſiſt of dulcified acetous acid, the next ounce will be almoſt all ether, and the whole quantity of ether produced will be near four ounces.

Acetous ether is not nearly ſo volatile as the nitrous or vitriolic. It burns with a blue flame like ardent ſpirit.

The acid obtained by diſtillation from wood likewiſe affords an ether remarkable in its quantity, which conſiderably exceeds that of the ardent ſpirit made uſe of*. For this purpoſe the acid may be diſtilled from beech wood, rectified a ſecond time, and then ſaturated with fixed alkali. Three pounds of the acid require about five ounces of purified alkali (I ſuppoſe mild). By evaporation to dryneſs, ſlight fuſion, with ſubſequent ſolution, filtration, and evaporation, three ounces and a quarter of a foliated neutral ſalt are obtained. The concentrated acid of wood may be diſengaged from this by diſtillation with two ounces of vitriolic acid; and the quantity of acid of wood thus obtained weighs one ounce and three quarters. By mixing this with an equal quantity of pure ardent ſpirit, and diſtilling with a ſmall retort, near two ounces and a quarter of ether are obtained.

A mixture of one ounce of the diſtilled acid of wood ſorrel with an equal quantity of ardent ſpirit, afforded by diſtillation three drams of ether, in the

* Weigleb, p. 521.

hands

hands of Savary. The cryſtallized ſaccharine acid diſtilled with an equal portion of ardent ſpirit, afforded Bergman, firſt, ardent ſpirit, then an acid liquor, which by evaporation yielded cryſtallized ſaccharine acid and precipitated lime-water, and on the top of which floated a thin ſtratum of ether, that acquired a blue tinge from calx of copper, and did not take fire until previouſly heated. Its flame was blue.

An ethereal liquor was obtained by Crell, by gentle diſtillation of equal parts of acid of fat and ardent ſpirit. The phoſphoric acid does not produce ether by direct combination with ardent ſpirit; but the combination is ſaid to take place by diſtilling a due mixture of ardent ſpirit, microcoſmic ſalt, and vitriolic acid, the phoſphoric acid being probably expelled from its baſe in a higher ſtate of acidification than it poſſeſſes when obtained by ſuffering phoſphorus to deliqueſce in the air. An ether is alſo afforded by the acid of ants, treated in the ſame method as the acetous acid.

The acid of benzoin does not produce ether by ſimple digeſtion with ardent ſpirit; but when one part of the acid of benzoin is diſtilled with three of ardent ſpirit, and half a part of common marine acid, pure ſpirit comes firſt over, and afterwards an ethereal combination, part of which floats at the top, and part ſinks to the bottom. This is not more volatile than acetous ether, and burns with a bright flame and ſmoke.

Notwithſtanding the great improvements of modern chemiſtry, we are ſtill in a great meaſure at a loſs reſpecting the true theory of ethers. It was formerly thought, that the acid merely deprived the ſpirit of a portion of combined water, which prevented it from exhibiting oleaginous properties. It appears, however, to be aſcertained at preſent, that all ethers contain a portion of that peculiar acid, by whoſe action the ſpirit was changed, as may be ſhewn by ſuffering them to evaporate, by burning them upon water, or by proper re-agents: and it is alſo obſervable, that in ſome inſtances the quantity of ether exceeds that of the ardent ſpirit. Chaptal, in his Elements of Chemiſtry, aſſerts with confidence, that ether is nothing but a combination of ardent ſpirit and vital air, and adduces a very curious experiment, wherein he obtains an ethereal liquor by repeated diſtillations of good alcohol from the red calx of mercury. Valuable, however, as this fact appears to be, it is by no means concluſive in favour of his opinion, which is overthrown, as to its generality, by the remarkable differences in the properties of the ſeveral ethers, and the peculiar acids ſeparable from them. Dr. Dollfuſs, quoted by Hopſon *, in his notes to Weigleb's General Syſtem of Chemiſtry, infers that the acid made uſe of, does, by a proceſs analogous to combuſtion, convert the vegetable acid of the ſpirit into a coal, while another part of the ſame firſt-mentioned acid combines with the diſengaged oleaginous part of the ſpirit, and forms a ſubtle ſoap or ether. And this theory is with conſiderable acuteneſs modified by Dr. Hopſon, who concludes, that the acid converts ardent ſpirit into ether by the operation of double affinity; that is to ſay, admitting that ardent ſpirit conſiſts of the baſes of inflammable and fixed air, or the vegetable principle, in combination, as inferred from Mr. Lavoiſier's analyſis by combuſtion †; he judges, that the vital air of the acid made uſe of unites with the vegetable principle, and forms acid of tartar and vinegar, while the baſis of

* P. 512.

† Acad. Par. 1781, and 1784.

the

the ſame acid combines with the inflammable baſis of the ardent, and forms ether which is properly an oil.

ETHIOPS, MARTIAL. Iron in the form of a very ſubtle powder, and in the firſt ſtage of calcination. It was introduced into medicine under this name by the younger Lemery, and is thus made: Very clean iron filings are to be put into a glaſs veſſel, and covered with water to the depth of two or three inches. In this ſituation they are to be frequently agitated, until a conſiderable portion has acquired the form of a black powder, eaſily ſuſpended in the water. By decantation of the turbid water, and ſubſequent repoſe, the black powder may be obtained ſeparate, which is afterwards to be dried by heat in a glaſs retort, and ground fine upon porphyry.

The ethiops appears to be produced by the concurrent action of the air and water: for this laſt, when pure, acts very little upon iron. It was formerly ſuppoſed to poſſeſs peculiar advantages as a medicine; but there is no reaſon to think that the degree of calcination, in which only it differs from the other calces of iron, is of much conſequence to the medical exhibition of this metal.

The martial ethiops is in a ſtate ſo nearly approaching that of the pure metal, that it obeys the magnet, and was uſed by Dr. Knight, to make artificial load-ſtones, by kneading it up with linſeed oil.

ETHIOPS, MINERAL. A combination of mercury and ſulphur. It is black, and may be made either by triturating, in a glaſs or earthen veſſel, two parts of mercury with three of flowers of ſulphur, till the mercury has diſappeared; or otherwiſe, by fuſing ſulphur in an unglazed earthen veſſel, taking it from the fire, and mixing an equal weight of mercury by ſtirring the maſs with a ſpatula till it is cold. It is then to be pounded and ſifted.

Mercurial ethiops is ſaid not to differ from cinnabar, except in the proportion of the materials. It ſeems probable, however, that the mercury may be more calcined in the latter than in the former compound.

Lemery ſays, that half the materials are loſt when the ethiops is made by fire: but it is probable that this muſt have ariſen from ſomething in the management; for the whole loſs in the cinnabar manufactory is leſs than one fortieth part. *See* CINNABAR.

The ethiops mineral has been given in aſthma, ſcrophula, and other diſeaſes ariſing from obſtruction. It is at preſent little regarded, and may certainly be conſidered of little efficacy, if attention be paid to the large doſes which may be taken of this ſubſtance, with little apparent effect on the patient.

EVAPORATION. A chemical operation uſually performed by applying heat to any compound ſubſtance, in order to diſpel the volatile parts. It differs from diſtillation in its object, which chiefly conſiſts in preſerving the more fixed matters, while the volatile ſubſtances are diſſipated and loſt. And the veſſels are accordingly different, evaporation being commonly made in open ſhallow veſſels, and diſtillation in an apparatus nearly cloſed from the external air.

The degree of heat muſt be duly regulated in evaporation. When the fixed and more volatile matters do not greatly differ in their tendency to fly off, the heat muſt be very carefully adjuſted: but in other caſes this is leſs neceſſary.

As evaporation conſiſts in the aſſumption of the elaſtic form, its rapidity will be in proportion to the degree of heat and the diminution of the preſſure of the atmoſphere. A current of air is likewiſe of ſervice in this proceſs; partly from its abſorbing the vapours, by combining with them as they riſe, and partly from

the convenience attending the ſpeedy removal of theſe vapours when of a noxious or corroſive nature.

EUDIOMETER. An inſtrument for aſcertaining the purity of air, or rather the quantity of vital or truly reſpirable air contained in any given bulk of elaſtic fluid. Dr. Prieſtley's diſcovery of the great readineſs with which nitrous air combines with dephlogiſticated or vital air, and by that means becomes precipitated in the form of nitrous acid (ſee ACID, NITROUS; alſo AIR, ATMOSPHERICAL), is the baſis upon which almoſt every inſtrument of this kind has hitherto been conſtructed.

Mr. Cavendiſh, in the Philoſophical Tranſactions *, gives his opinion in favour of the eudiometer of the Abbé Fontana, chiefly becauſe the tube in which the mixture is made is long and narrow, and the other parts are ſo formed and adjuſted, that the air riſes ſlowly in one continued column up the tube—advantages which afford time to ſeparate the tube from the reſt of the apparatus, and ſhake it before the airs come quite in contact; by which means the diminution is much greater and more ſpeedy than it would otherwiſe be.

For inſtance, if equal meaſures of common and nitrous air be mixed in this manner, the bulk of the mixture will in general be about one meaſure: whereas, if the airs be ſuffered to remain in contact about one fourth of a minute before they are ſhaken, the bulk of the mixture will be hardly leſs than one meaſure and two tenths; and will be very different accordingly as it is ſuffered to remain, a little more or a little leſs time, before it is ſhaken. In like manner the reſult will be varied, if by any fault in the apparatus the air be ſuffered to riſe in bubbles; becauſe in this caſe it will not be poſſible to agitate it ſoon enough.

The ſpeedy acquiſition of the maximum of diminution is another great advantage in the method; and the whole is well explained by Mr. Cavendiſh, who concludes, that they depend on the preſence of the water, which at the very inſtant of the combination of the airs is by the agitation brought every where into contact with the precipitated nitrous acid, and conſequently abſorbs it with readineſs and facility.

The eudiometer of Mr. Cavendiſh conſiſts of the following apparatus: A (plate II. fig. 2.) is a cylindrical glaſs veſſel, with braſs caps at top and bottom; to the upper cap is fixed a braſs cock, B: the bottom cap is open, but is made to fit cloſe into the braſs ſocket D d, and is fixed in it in the ſame manner as a bayonet is on a muſket. The ſocket D d has a ſmall hole in its bottom, and is faſtened to the board of the pneumatic tub (fig. 3. pl. I.) by the bended braſs F f G, in ſuch manner, that b the top of the cock is about half an inch under water. Conſequently if the veſſel A be placed in its ſockets with any quantity of air in it, and the cock be then opened, the air will run out by the cock, but will do ſo very ſlowly, as it can eſcape no faſter than the water can enter by the ſmall hole E to ſupply its place.

Beſides this veſſel b, there are three glaſs bottles M (fig. 3), each with a flat braſs cap at bottom to make it ſtand ſteady, and a ring at top to ſuſpend it by, and alſo ſome meaſures of different ſizes, ſuch as B (fig. 4). Theſe are of glaſs, with a flat braſs cap and a wooden handle. In uſing them they are filled with the air required to be meaſured, and then ſet upon a braſs knob, c, fixed on the ſhelf

* Vol. lxxiii. p. 107.

of

of the apparatus below the ſurface of the water. This knob drives out ſome of the air, and leaves only the proper quantity.

The author uſes two different methods of mixing the airs: the firſt is, to add the reſpirable air ſlowly to the nitrous; and the other to add the nitrous in the ſame manner to the reſpirable. He moſt commonly uſes the firſt. In this method a proper quantity of nitrous air is put into one of the bottles M, by means of one of the meaſures here deſcribed; and a proper quantity of reſpirable is let into the veſſel A, by firſt filling it with this air, and then ſetting it on the knob C, as was done by the meaſure. The veſſel A is then fixed in the ſocket, and the bottle M placed with its mouth over the cock. Then on opening the cock, the air in the veſſel A runs ſlowly in ſmall bubbles into the bottle M, which is kept ſhaking all the time by moving it backwards and forwards horizontally, while the mouth ſtill remains over the cock.

The errors ariſing from a greater quantity of water remaining adherent to the inſide of the meaſures and tubes in eudiometers at one time than another, are found to be very conſiderable. Mr. Cavendiſh obviates them by aſcertaining the diminution of bulk from the weight of water admitted into the veſſels. For this purpoſe he ſuſpends a forked wire from one end of a balance, placed ſo as to hang over the tub of water, to each end of which fork is fixed a fine copper wire. In trying the experiment, the veſſel A, with the reſpirable air in it, is firſt weighed by ſuſpending it from one of theſe copper wires, in ſuch manner as to remain entirely under water. The bottle M, with the proper quantity of nitrous air in it, is then hung on in the ſame manner to the other wire, and the weight of both together found. The air is then let out of the veſſel A into the bottle M, and the weight of both veſſels found again, the increaſe of weight being that of a volume of water equal in magnitude to the air which has diſappeared by the combination. Laſtly, the bottle M is taken off, and the veſſel A weighed by itſelf, which gives the quantity of reſpirable air made uſe of by a ſimilar increaſe in its weight. Care muſt be taken in this method that the ſurfaces of the air in both veſſels be nearly or abſolutely on the ſame level, that the preſſure of the ſuperincumbent water may be equal on both.

I have given an account of this eudiometer and the method of uſing it, becauſe in fact it appears to poſſeſs the means of greater accuracy than any other. The whole paper is highly deſerving of the attention of philoſophers.

EUPHORBIUM. A gummy reſin exſuding from a large oriental ſhrub, Euphorbia officin. Linn.

It is brought to us immediately from Barbary, in drops of an irregular form; ſome of which, upon being broken, are found to contain little thorns, ſmall twigs, flowers, and other vegetable matters; others are hollow, without any thing in their cavity; the tears in general are of a pale yellow colour externally, ſomewhat white withinſide: they eaſily break betwixt the fingers. Lightly applied to the tongue, they affect it with a very ſharp biting taſte; and, upon being held for ſome time in the mouth, prove vehemently acrimonious, inflaming and exulcerating the fauces, &c. Euphorbium is extremely troubleſome to pulverize, the finer part of the powder which flies off, affecting the head in a violent manner. The acrimony is ſo great as to render it abſolutely unfit for any internal uſe. Several correctors have been contrived to abate its virulence, but the beſt of them are not to be truſted to; and as there ſeems to be no real occaſion for it,

unleſs

unleſs for ſome external purpoſes, we think with Hoffman and others, that it ought to be expunged from the catalogue of internal medicines.

EXCREMENTS. However important the knowledge of the component parts of fecal matter may be, to facilitate our acquaintance with the animal ſyſtem, it may eaſily be imagined, that the purſuits of the majority of chemiſts would be directed to departments of the ſcience which promiſed effects of a leſs unpleaſant nature. We poſſeſs but one ſet of experiments made on this ſubject by Homberg at the beginning of the preſent century. This philoſopher, in conſequence of alchemiſtical information, inſtituted a ſet of operations upon the fecal matter of men fed entirely upon the bread of Goneſſe * and Champaigne wine. He found, that, when recent, it afforded by diſtillation to dryneſs an aqueous, clear, inſipid liquor of a diſagreeable odour, which contained no volatile alkali; but, by continuing to diſtil the reſidue by a graduated fire, he obtained fluid and concrete volatile alkali, a fetid oil, and a coaly reſidue; ſubſtances which this imperfect method of analyſis exhibits with every kind of animal ſubſtance.

The human fecal matter, by lixiviation in water, filtration, and ſubſequent evaporation, afforded an oily ſalt reſembling nitre, which was fuſed on ignited coals, and took fire when heated to a certain degree in cloſed veſſels. The ſame fecal matter, after it had undergone a complete putrefaction for forty days in the gentle heat of a water bath, afterwards afforded by diſtillation a colourleſs oil without ſmell, which was the thing ſought after; but it did not fix mercury, as he had been led to expect.

Imperfect as this examination is, it is rendered ſtill leſs generally applicable by the peculiar nature of the aliments from which the matter originated. For it cannot be doubted, but that, as the excrements are the reſidue of the food taken, they will differ according to the nature of that food, as is indeed ſufficiently evinced from their more obvious qualities.

EXPANSION. All bodies expand by heat; but the differences are exceedingly great between ſome bodies and others. Whether this difference may depend upon, or be connected with, any of the other known properties of the ſeveral bodies, cannot be inferred from any experiments yet made. Of all ſubſtances hitherto examined, it is found that the vegetable fibre varies its dimenſions lengthwiſe the leaſt by change of temperature; for which reaſon a ſtraight-grained rod of deal wood is found to be much preferable to any other ſimple ſubſtance in the conſtruction of pendulums for clocks. This ſame object, namely, the conſtruction of pendulums, together with other circumſtances relative to geometrical admeaſurements, have rendered it of ſome importance to aſcertain the proportional expanſions of metals, and ſome other bodies, by change of temperature. There are two ways of doing this. The firſt, practiſed by Muſſchenbroek, Ellicott, and many others, conſiſts in the application of a train of wheels or levers, which magnify the motion by the increaſed velocity of the extreme part of the train. The other contrivance, by Ramſden, conſiſts in placing two microſcopes above the body whoſe dimenſions are required to be aſcertained; and as theſe inſtruments are fixed to a bar of caſt iron conſtantly kept at the freezing temperature by ſurrounding it with melting ice, their diſtance does not vary from this

* A ſmall town near Paris, where the moſt excellent bread is made.

cauſe. The laſt method, practiſed by General Roy *, is much preferable to any other hitherto carried into effect; and it is much to be regretted that the ſubſtances examined by the General were ſo few in number. He found that the expanſions of the following ſubſtances, in each foot of length, by a change of temperature of 180 degrees of Fahrenheit's thermometer, that is to ſay, from the freezing to the boiling points of water, were as under.

Standard braſs ſcale, length 42·187. It expanded per foot 0·0222646 inch.

Engliſh plate braſs rod 5 feet long, difficult from its thinneſs to be kept free from warping, expanded per foot 0·0227136 inch.

Engliſh plate braſs in form of a trough, perfectly ſtrong, expanded per foot 0·0227386 inch.

Steel rod 5 feet long expanded per foot 0·0137368 inch.

Caſt iron priſm 5 feet long expanded per foot 0·0133126 inch.

Glaſs tube 5 feet long expanded per foot 0·0093138 inch.

Solid glaſs rod 40½ inches long expanded per foot 0·0096944 inch.

The braſs ſcale was ſuppoſed to be Hamburgh braſs.

The makers of aſtronomical regulators availed themſelves of the difference of expanſion of braſs and ſteel to make pendulums, whoſe centres of oſcillation remain at an invariable diſtance from their reſpective centres of ſuſpenſion. Portable time-pieces are likewiſe made to aſcertain the longitude at ſea with conſiderable preciſion, by forming the rim or circular part of the balance of braſs and ſteel ſoldered together, the ring of braſs being outermoſt. The effect of two ſuch pieces of metal being ſoldered together is, that they change their figure by change of temperature. For it may eaſily be underſtood, that when a rod of braſs is firmly ſoldered to a rod of ſteel, and the temperature of both be raiſed, the greater expanſion of the braſs will cauſe that ſide of the compound bar to be longer than the oppoſite ſide which is ſteel. And this cannot take place without bending of the bar, which accordingly takes place, the braſs ſide becoming convex. A diminution of temperature reſtores the original figure, and a ſtill greater degree of diminution muſt of courſe bend it the contrary way.

The conſtruction of time-pieces is very remotely related to the purſuits of the chemiſt; but there is no department of ſcience which cannot indicate uſeful truths to the cultivators of other branches: this ingenious application of the differences of expanſion in metals is here mentioned as a hint to the chemiſt, who may eaſily apply it in the conſtruction of a thermometer for meaſuring the degrees of heat by the actual ignition of two metals rivetted, or otherwiſe faſtened together.

EXPRESSION, *or* PRESSURE. The juices of vegetables, and the fluid parts of other ſoft ſubſtances, are obtained by putting them into a cloth or bag, and expoſing it to the action of the preſs.

EXTRACT. When decoction is carried to that point as to afford a ſubſtance either ſolid or of the conſiſtence of paſte, this reſidual product is called an extract. When chemiſts ſpeak of extract or extractive matter, they moſt commonly mean the product of aqueous decoction; but the earlier chemiſts frequently ſpeak of ſpirituous extract.

* Philoſophical Tranſactions, vol. lxxv.

F.

FARINA.—*See* BREAD.

FAT. The fat of animals is a ſubſtance of the ſame nature as thoſe oils which are called fat oils in the vegetable kingdom. Its conſiſtence is various in different animals, and in different parts of the ſame animal. The fat of the human ſpecies and of quadrupeds is conſiſtent, and of a white or yellowiſh colour; the fat of the internal parts being uſually firmer than that which is placed among the muſcles. It poſſeſſes all the characters of vegetable fat oils, though the crude fat of animals appears to contain a conſiderable quantity of mucilage or jelly peculiar to that kingdom, which may for the moſt part be waſhed off by agitation in a large quantity of hot water.

Neumann treated the fat of the gooſe, the hog, the ſheep, and the ox, in a glaſs retort by a fire gradually raiſed. He obtained phlegm, an empyreumatic and browniſh oil, and a brilliant coal. This analyſis led him no farther than to the concluſion, that there is little difference between fats. But modern experimentshave ſhewn that it contains an acid of a peculiar nature, for an account of which ſee ACID OF FAT.

FEATHERS. We do not poſſeſs experiments that point out any difference between feathers and the other animal coverings, when chemically conſidered. The horns, hair, and feathers of animals are more conſiſtent than the ſkin and muſcular parts, and appear to contain leſs gelatinous matter. Perhaps they may, on due enquiry, be found to contain a large portion of ſerum. Neumann found that feathers afforded more volatile alkali than hair or wool, but leſs than ſilk. Cauſtic alkali combines with them by boiling.

FELT SPAR. An hard ſtone of the ſiliceous claſs, called likewiſe Scintillating Spar, Fuſible Spar, and Rhombic Quartz. It is generally opake, white, red, yellow, brown, green, violet, or irideſcent; ſometimes cryſtallized in rhombic, cubic, or parallelopipedal forms, and often irregular. Its texture, though cloſe, is lamellated, and it breaks like ſpar. Its ſpecific gravity is from 2400 to 2600; its hardneſs ſufficient to give fire with the ſteel, though it is leſs than that of quartz.

Kirwan aſſures us that it is more fuſible without addition than the fluors, and forms a whitiſh glaſs which does not act on the crucibles. Borax and microcoſmic ſalt diſſolve it totally in the dry way without effervеſcence, but it does not eaſily combine with fixed alkalis. The cryſtallized ſort decrepitates in the fire.

It never conſtitutes veins or ſtrata, but is either found in looſe maſſes at moſt two inches long, or mixed with ſand or clay, or embodied in other ſtones, as granites.

One hundred parts of the white contain about 67 of ſiliceous earth, 14 of argillaceous, 11 of ponderous, and 8 of magneſia.

Mr. Kirwan ſays, that this is undoubtedly the petuntſe made uſe of by the Saxons in their porcelain manufactories.

The Labrador ſtone is a beautiful ſpecies of this ſtone, exhibiting a variety of

colours according to the poſition of the eye of the obſerver, and the direction of the light which falls upon it.

FERMENT. *See* FERMENTATION.

FERMENTATION. This word was formerly uſed in a very undefined and general ſenſe, to denote every change undergone by organized ſubſtances, of which the cauſe was not apparent; ſuch as chemiſts are apt to call by the name of ſpontaneous changes. But it is at preſent confined almoſt excluſively to the changes which ſaccharine matters undergo in certain ſituations of temperature and moiſture. The putrefaction of animal bodies is likewiſe not unfrequently termed the putrefactive fermentation; though it would be perhaps more uſeful to confine this word to ſaccharine matter.

Fermentation has been diſtinguiſhed into three ſtages: the vinous or ſpiritous, the acid or acetous, and the putrid or putrefactive; which are ſo called from the principal products afforded during each of them reſpectively. It is aſcertained almoſt beyond a doubt, that the vinous fermentation takes place only in ſuch bodies as contain ſaccharine juices. In this the moſt remarkable product is that volatile, light, colourleſs, inflammable fluid which mixes with water in all proportions, and is called ardent ſpirit. The acetous fermentation is diſtinguiſhed by the product known by the name of vinegar, which is the leaſt deſtructible of the mere vegetable acids. It does not appear, however, that fermentation is abſolutely neceſſary for the production of this acid, which may be had by treating various organized bodies with nitrous acid. In the putrid fermentation theſe bodies appear to be reduced into very ſimple principles. Volatile alkali is the product which has been remarked as the chief in this proceſs, and is doubtleſs produced by the combination of inflammable and phlogiſticated air, which fly off in this proceſs. It may alſo be had in a variety of direct chemical proceſſes.—*See* ALKALI, VOLATILE.

The acetous like the vinous fermentation is confined to vegetable ſubſtances; but the putrefactive proceſs is moſt eminently perceived in animal bodies. Theſe either putrefy immediately without any other previous change, or, if the putrefaction be preceded by either of the other ſtages, their duration and intenſity are inſenſible. It is conſidered as an eſtabliſhed fact, that the three ſtages of fermentation always follow each other in the ſame order in ſuch bodies as are ſuſceptible of them all; the vinous coming firſt, which is followed by the acetous and putrefactive proceſſes.

Theſe ſpontaneous effects are greatly retarded by extreme cold, or by ſudden deſiccation, or by preſervation of the bodies in veſſels ſo well cloſed as to prevent the eſcape or abſorption of elaſtic fluid. The two firſt of theſe neceſſarily retard the chemical proceſſes, by depriving the parts of the requiſite fluidity; and it may without difficulty be underſtood, that the changes of combination cannot by any means be completely made, while the communication with the open air, the great receptacle and ſolvent of volatile matter, and one of the chief agents in the great operations of nature, is cut off.

The three conditions for the due accompliſhment of fermentation will therefore be, fluidity, or moiſture; moderate heat, or a due temperature; and the acceſs of air. It will of courſe be modified alſo by the component parts of the body itſelf.

As

As the vinous fermentation has never been found to take place where ſugar was not preſent, it appears the moſt ſimple to conſider what happens when mere ſugar and water in due proportions are expoſed to fermentation. If a conſiderable quantity of water, holding in ſolution about one-third of its weight of ſugar, be expoſed to the air, at the temperature of about 70 degrees of Fahrenheit's thermometer, after the addition of a ſmall quantity of yeaſt, it ſoon undergoes a remarkable change. In the courſe of a few hours the fluid becomes turbid and frothy; bubbles of fixed air are diſengaged, which riſe and break at the ſurface. This diſengagement becomes more and more abundant; mucilage is ſeparated; part of which ſubſides to the bottom, and part, expanded into froth by the elaſtic fluid, forms yeaſt. During the courſe of ſeveral days theſe effects gradually come to their height, and diminiſh again; after which they proceed very ſlowly, but are long before they entirely ceaſe. The fermented liquor has no longer the ſweet taſte it had before; but becomes briſk and lively, with a pungent ſpirituous flavour. Its ſpecific gravity is likewiſe conſiderably leſs than before; and when expoſed to diſtillation, it affords a light inflammable ſpirit miſcible with water in all proportions. The quantity of ardent ſpirit which any fermented liquor will produce, is thought to follow ſome proportion of the change its ſpecific gravity undergoes in fermentation; but the truth of this has not been clearly aſcertained. Wine, cyder, and beer are well known liquors of this kind.

When it is required to preſerve fermented liquors in the ſtate produced by the firſt ſtage of fermentation, it is uſual to put them into caſks before the vinous proceſs is completely ended; and in theſe cloſed veſſels a change very ſlowly continues to be made for many months, and perhaps for ſome years.

But if the fermentative proceſs be ſuffered to proceed in open veſſels, more eſpecially if the temperature be raiſed to 90 degrees, the acetous fermentation comes on. In this the vital air of the atmoſphere is abſorbed; and the more ſpeedily in proportion as the ſurfaces of the liquor are often changed by lading it from one veſſel to another. The uſual method conſiſts in expoſing the fermented liquor to the air in open caſks, whoſe aperture at the bung is covered with a tile to prevent the entrance of the rain. By the abſorption of vital air which takes place, the inflammable ſpirit becomes converted into an acid. If the liquid be then expoſed to diſtillation, pure vinegar comes over inſtead of ardent ſpirit.

When the ſpontaneous decompoſition is ſuffered to proceed beyond the acetous proceſs, the vinegar becomes viſcid and foul; air is emitted with an offenſive ſmell; volatile alkali flies off; an earthy ſediment is depoſited; and the remaining liquid, if any, is mere water. This is the putrefactive proceſs.

Modern diſcoveries have greatly elucidated the phenomena of fermentation; but much ſtill remains to be accurately determined concerning the proceſſes, the products, and their proportions. It is not clearly aſcertained what the yeaſt or ferment performs in this operation. It ſeems probable, that the fermentative proceſs in conſiderable maſſes would be carried on progreſſively from the ſurface downwards; and would, perhaps, be completed in one part before it had perfectly commenced in another, if the yeaſt, which is already in a ſtate of fermentation, did not cauſe the proceſs to begin in every part at once. *See* BREAD, PUTREFACTION, TARTAR, SPIRIT ARDENT, WINE, VINEGAR, VEGETABLE KINGDOM.

FIL-

FILTRATION. An operation, by means of which the greateſt part of a fluid is mechanically ſeparated from ſuch conſiſtent particles as may be merely mixed with it. It does not differ from ſtraining.

An apparatus fitted up for this purpoſe is called a filter. The form of this is various, according to the intention of the operator. A piece of tow, or wool, or cotton, ſtuffed into the pipe of a funnel, will prevent the paſſage of groſſer particles, and by that means render the fluid clearer which comes through. Spunge is ſtill more effectual. A ſtripe of linen rag wetted and hung over the ſide of a veſſel containing a fluid, in ſuch a manner as that one end of the rag may be immerſed in the fluid, and the other end may remain without, below the ſurface, will act as a ſyphon, and carry over the clearer portion. Linen or woollen ſtuffs may either be faſtened over the mouths of proper veſſels, or fixed to a frame, like a ſieve, for the purpoſe of filtering. All theſe are more commonly uſed by cooks and apothecaries than by philoſophical chemiſts, who, for the moſt part, uſe the paper called cap paper, made up without ſize.

As the filtration of conſiderable quantities of fluid could not be effected at once without breaking the filter of paper, it is found requiſite to uſe a linen cloth, upon which the paper is applied and ſupported.

Precipitates and other pulverulent matters are collected more ſpeedily by filtration than by ſubſidence. But there are many chemiſts who diſclaim the uſe of this method, and avail themſelves of the latter only, which is certainly more accurate, and liable to no objection where the powders are ſuch as will admit of edulcoration and drying in the open air.

FIRE. The word heat has been uſed with ſo much preciſion by Doctors Black, Irvine, Crawford, and others, that the word fire ſeems to have been rendered of little uſe, except to denote a maſs of matter in a ſtate of combuſtion, which is, indeed, its vulgar acceptation. The term has, however, been uſed by many eminent writers, to denote what theſe great philoſophers call the matter of heat. —For which ſee the article HEAT.

FISH. It appears from the experiments of Neumann, that fiſh afford more volatile alkali by deſtructive diſtillation than the fleſh of land animals does. Lobſters and other ſhell fiſh have been thought to contain a diſengaged alkali; but this may with juſtice be doubted.

FIXITY. The property by which bodies reſiſt the action of heat, ſo as not to riſe in vapour. It is the oppoſite to volatility. The fixity of bodies appears to be merely relative, and depends on the temperature at which they aſſume the elaſtic ſtate or form. Such bodies as aſſume this ſtate at a low temperature will eaſily riſe; whereas thoſe which cannot be ſo dilated but at an extreme heat, will remain fixed in all ordinary ſituations. From the analogy of a variety of facts, it does not ſeem probable that any ſubſtances are abſolutely fixed.

Fixed bodies are, for the moſt part, denſer than thoſe which are more volatile. The planets neareſt the ſun are alſo found to be denſer than thoſe which are more remote, and are certainly formed of more fixed materials, as far as our experiments of heat on the ſolids and fluids of this globe can aſſure us.

FLAME. Newton and others have conſidered flame as an ignited vapour, or red hot ſmoke. This, in a certain ſenſe, may be true, but, no doubt, contains an inaccurate compariſon. Simple ignition never exceeds in intenſity of light the body by contact of which it was produced. But it appears to be well

aſcertained, that flame always conſiſts of volatile inflammable matter in the act of combuſtion and combination with the vital part of the atmoſphere. Many metallic ſubſtances are volatilized by heat, and burn with a flame by the contact of the air in this rare ſtate. Sulphur, phoſphorus, and ſome other baſes of acids exhibit the ſame phenomenon. But the flames of organized ſubſtances are in general produced by the extrication and accenſion of inflammable air with more or leſs of charcoal. When the circumſtances are not favourable to the perfect combuſtion of theſe products, a portion of the coal paſſes through the luminous current unburned, and forms ſmoke. Soot is the condenſed matter of ſmoke.

As the artificial light of lamps and candles is afforded by the flame they exhibit, it ſeems a matter of conſiderable importance to ſociety to aſcertain how the moſt luminous flame may be produced with the leaſt conſumption of combuſtible matter. There does not appear to be any danger of error in concluding that the light emitted will be greateſt when the matter is completely conſumed in the ſhorteſt time. It is therefore neceſſary that a ſtream of volatilized combuſtible matter of a proper figure, at a very elevated temperature, ſhould paſs into the atmoſphere with a certain determinate velocity. If the figure of this ſtream ſhould not be duly proportioned; that is to ſay, if it be too thick, its internal parts will not be completely burned for want of contact with the air. If its temperature be below that of ignition, it will not burn when it comes into the open air. And there is a certain velocity at which the quantity of atmoſpherical air which comes in contact with the vapour will be neither too great nor too ſmall; for too much air will diminiſh the temperature of the ſtream of combuſtible matter ſo much as very conſiderably to impede the deſired effect, and too little will render the combuſtion languid.

We have an example of a flame too large in the mouths of the chimneys of furnaces, where the luminous part is merely ſuperficial, or of the thickneſs of about an inch or two, according to circumſtances, and the internal part, though hot, will not ſet fire to paper paſſed into it through an iron tube; the ſame defect of air preventing the combuſtion of the paper as prevented the interior fluid itſelf from burning. And in the lamp of Argand we ſee the advantage of an internal current of air, which renders the combuſtion perfect by the application of air on both ſides of a thin flame. So likewiſe a ſmall flame is whiter and more luminous than a larger; and a ſhort ſnuff of a candle giving out leſs combuſtible matter in proportion to the circumambient air, the quantity of light becomes increaſed to eight or ten times what a long ſnuff would have afforded.

FLINT. A ſemi-tranſparent hard ſtone, of the ſiliceous order, of a greyiſh, black, or yellowiſh colour, well known for its general utility in giving fire with the ſteel. It is commonly found in nodules, in beds of chalk or ſand, and frequently exhibits indications of its having been in a ſoft ſtate. Some ſpecimens are hollow, and internally lined with ſiliceous cryſtals. By long expoſure on the ſurface of the ground, they gradually become white on their upper ſurface firſt, and afterwards all over. This whiteneſs, in proceſs of time, penetrates into the ſubſtance of the flint, forming a cruſt ſometimes one-twentieth of an inch thick, which may be ſcraped with a knife. It has been ſaid that this is a converſion of flint into calcareous earth; but I know of no proof of the fact; and as this white matter does not appear to be affected by nitrous acid, I am inclined to think that the flint is merely ſhattered by the weather in a manner ſomewhat analogous

analogous to the effect of ignition and quenching in water, which renders it white and friable.

Weigleb found the common flint to contain 80 parts in the 100 ſilex, 18 clay, and 2 lime. It is uſed in making glaſs and pottery.

A ſolution of ſiliceous earth, made by fuſing flints with a large proportion of fixed alkali, and diſſolving the maſs in water, is called liquor of flints.

FLOOR. The lower part of a mine is called the floor, and the upper the roof.

FLOUR. The powder of the gramineous ſeeds. Its uſe as food is well known. *See* BREAD.

FLOWERS. A general appellation ſtill retained from the elder chemiſts, and uſed to denote all ſuch bodies as have received a pulverulent form by ſublimation. Thus we have the flowers of antimony, of arſenic, of benzoin, of ſal-ammoniac, of ſulphur, of zinc, &c. which may be reſpectively conſulted.

FLOWERS OF VEGETABLES. Dr. Lewis, in his notes on Neumann's Chemiſtry, gives a curſory account of many experiments made with a view to aſcertain how far the colour of vegetable flowers might prove of uſe to the dyer. He found very few capable of being applied to very valuable purpoſes. Many of the blue flowers gave out their colour to water, but none that he tried gave a blue tinge to ardent ſpirit. No preparation offered itſelf with blue flowers, but the green lake afforded by adding lime water to the aqueous infuſion. The red flowers gave, in general, their colour to water, but it was periſhable; and his other experiments with theſe were not more productive of advantage than thoſe upon the blue. Yellow flowers, whether pale or deep, afforded a colour in general durable. Water and ardent ſpirit both extracted it. Neither acids nor alkalis were found to change its ſpecies, though they varied the ſhade; the acids rendering it paler, and the alkalis deeper. White flowers afforded a green tincture with alkalis; but whether of value or not the Doctor does not ſay.

FLUIDITY. The ſtate of bodies when their parts are very readily moveable in all directions with reſpect to each other. Many uſeful and curious properties ariſe out of this modification of matter, which form the baſis of the mechanical ſcience called hydroſtatics, and are of conſiderable importance in chemiſtry. But the attention of the chemiſt is chiefly directed to the ſtate of fluidity as it may affect the component parts of bodies.

A ſolid body may be converted into a fluid by heat. The leſs the temperature at which this is effected, the more fuſible the body is ſaid to be.

All fluids, not excepting the fixed metals, appear, from various facts, to be diſpoſed to aſſume the elaſtic form, and that the more readily the higher the temperature. When a fluid is heated to ſuch a degree as that its elaſticity is equal to the preſſure of the air, its interior parts riſe up with ebullition.

The capacity of a denſe fluid for heat is greater than that of the ſame body when ſolid, but leſs than when in the elaſtic ſtate. If this were not the caſe, the aſſumption of the fluid and elaſtic ſtate would be ſcarcely at all progreſſive, but effected in moſt caſes inſtantly as to ſenſe. *See* HEAT.

The ſtate of denſe fluidity appears to be more favourable to chemical combination than either the ſolid or elaſtic ſtate. In the ſolid ſtate, the coheſive attraction prevents the parts from obeying their chemical tendencies, and in the elaſtic ſtate the repulſion between the parts has in a great meaſure the ſame effects. Hence

has been conſidered, though too haſtily, as a chemical axiom, that *corpora non agunt niſi fluida.*

FLUOR. This word has been uſed to diſtinguiſh ſuch bodies as are for the moſt part fluid in the temperature of the atmoſphere. Thus, for example, the fluor acids, the fluor volatile alkali, are terms ſometimes uſed; but in general the writers on chemiſtry have not adopted this word.

FLUOR SPAR. This ſpar is found of different colours, white, yellow, green, reddiſh, purple, brown, or colourleſs, more or leſs tranſparent, and ſerving as the matrix for the ores it envelops. Its texture is ſparry, or irregularly ſhattered, and its figure, when regular, cubical. Its hardneſs is not ſufficient to give fire with ſteel. Acids do not effervеſce with it, nor diſſolve it, unleſs when decompoſition takes place. Heat cauſes it to decrepitate; but it neither forms lime, plaſter, nor the Bolognian phoſphorus, by calcination. When it is placed in contact with a body conſiderably heated, though not ignited, it emits a phoſphoric light; but this experiment can ſcarcely be twice repeated with the ſame particles of the ſpar. A ſtrong heat fuſes it without addition, when it is found to act powerfully on the crucible, by virtue of its property of rendering argillaceous and other earths more fuſible. Its uſe as a flux in mine works has cauſed it to be called fluor or flux ſpar. All the three fluxes uſed with the blow-pipe diſſolve it without effervеſcence. It conſiſts of lime united to a peculiar acid.—*See* ACID OF FLUOR. The blue fluors derive their colour moſtly from iron, but ſometimes from cobalt. Moſt fluors, according to Kirwan, contain a mixture of argillaceous and ſiliceous earths, and ſome marine acid.

FLUX. A general term made uſe of to denote any ſubſtance or mixture added to aſſiſt the fuſion of minerals. In the large way, lime-ſtone or fuſible ſpar are uſed as fluxes; but in ſmall aſſays, the method of the great operations is not always followed, though it would be very frequently of advantage to do ſo. The fluxes made uſe of in aſſays or philoſophical experiments conſiſt uſually of alkalis, which render the earthy mixtures fuſible, by converting them into glaſs, or elſe glaſs itſelf in powder.

Alkaline fluxes are either the crude flux, the white flux, or the black flux. Crude flux is a mixture of nitre and tartar, which is put into the crucible with the mineral intended to be fuſed. The detonation of the nitre with the inflammable matter of the tartar is of ſervice in ſome operations; though generally it is attended with inconvenience on account of the ſwelling of the materials, which may throw them out of the veſſel, if proper care be not taken either to throw in only a little of the mixture at a time, or to provide a large veſſel.

White flux is formed by projecting equal parts of a mixture of nitre and tartar, by moderate portions at a time, into an ignited crucible. In the detonation which enſues, the nitrous acid is decompoſed, and flies off with the vegetable acid, and the remainder conſiſts of the vegetable alkali in a ſtate of conſiderable purity. This has been called fixed nitre.

Black flux differs from the preceding, in the proportion of its ingredients. In this the weight of the tartar is double that of the nitre; on which account the combuſtion is incomplete, and a conſiderable portion of the acid and tartar is decompoſed by the mere heat, and leaves a quantity of coal behind, on which the black colour depends. It is uſed where metallic ores are intended to be

reduced, and effects this purpoſe either by ſupplying the metal with phlogiſton, or rather by combining with the vital air of the calx.—*See* CALCINATION.

There is danger of loſs in the treatment of ſulphureous ores with alkaline fluxes: for, though much or the greateſt part of the ſulphur may be diſſipated by roaſting, yet that which remains will form an hepar with the alkali, which is a moſt powerful ſolvent of metallic bodies. The advantage of Mr. Morveau's reducing a flux ſeems to depend on its containing no uncombined alkali. It is made of eight parts of pulverized glaſs, one of calcined borax, and half a part of powder of charcoal. Care muſt be taken to uſe a glaſs which contains no lead. The white glaſſes contain in general a large proportion, and the green bottle glaſſes are not perhaps entirely free from it.

FORGE FURNACE. The forge furnace conſiſts of an hearth, upon which a fire may be made, and urged by the action of a large pair of double bellows, whoſe nozzle is inſerted through a wall or parapet conſtructed for that purpoſe. It is uſeful for applying a conſiderable heat with great expedition, and is accordingly very much uſed by blackſmiths and other artiſans. The philoſophical chemiſt will find it very uſeful for fuſions, reductions, and moſt other experiments that require a ſtrong heat, eſpecially if the veſſels be very ſmall. Black lead pots, or ſmall furnaces of every deſired form, may be placed as occaſions require upon the hearth; and the tube of the bellows being inſerted into a hole in the bottom of the furnace, it becomes eaſy to urge the heat to almoſt any degree required.

Mr. Wedgwood found the heat of a common ſmith's forge (I ſuppoſe without any addition to the fire-place) to be leſs than that required for the fuſion of caſt iron, and conſiderably below that of his ſmall air furnace.

A principal objection to this and every other furnace with bellows, is the labour of working them.

FRITT. The materials of glaſs are firſt mixed together, and then expoſed to calcination by a degree of heat not ſufficient to melt them. The maſs is then called fritt. The calcination deprives it of any accidental combuſtible matter it might have contained, and diſpoſes it to fuſion in the melting-pot with leſs effervescence than would elſe have taken place.

FRUITS OF VEGETABLES. In Dr. Lewis's examination of the colouring matters of vegetable fruits, he found that the red juices of fruits did not afford a permanent dye by any treatment he uſed. The dark dull ſtain of the black cherry proved conſiderably durable. SAP GREEN is prepared from the berries of buckthorn, and ANNOTTO is obtained from the pellicles of the ſeeds of an American tree. See the words.

FULIGINOUS. Vapours which poſſeſs the property of ſmoke, namely opacity, and the diſpoſition to apply themſelves to ſurrounding bodies in the form of a dark-coloured powder.

FULMINATING AND FULMINATION. In a variety of mercurial combinations, it happens, that one or more of the principles aſſume the elaſtic ſtate with ſuch rapacity, that the ſtroke againſt the diſplaced air produces a loud noiſe. This is called fulmination, or much more commonly detonation.

Fulminating gold, and fulminating powder, are the moſt common ſubſtances of this kind, except gunpowder. For the former and latter of theſe, ſee the articles

GOLD

GOLD and GUNPOWDER. The fulminating powder is made by triturating in a warm mortar three parts by weight of nitre, two of mild vegetable alkali, and one of flowers of ſulphur. Its effects, when fuſed in a ladle, and then ſet on fire, are very great. The whole of the melted fluid explodes with an intolerable noiſe; and the ladle is commonly disfigured, as if it had received a ſtrong blow downwards. A dram of the powder makes a report as loud as a cannon; but the noiſe of a few grains, or ſingle pinch taken between the finger and thumb, is very unpleaſant in a room. It has very little effect, unleſs firſt melted. A mixture of liver of ſulphur, with twice its weight of nitre, produces the ſame exploſion, though in leſs time: whence it appears, that the alkali and ſulphur of the former compoſition form a liver of ſulphur; and that the exploſion, in all probability, ariſes from the ſudden extrication of hepatic air from the liver of ſulphur, and vital air from the nitre, which burn the inſtant they are formed.

FURNACE. *See* APPARATUS.

FUSIBILITY. That property by which bodies aſſume the fluid ſtate. Such bodies as require a low heat for this purpoſe, are ſaid to be more fuſible than others which require a higher temperature to produce the ſame effect. Bodies vary greatly in their fuſibility. No experiments have yet been made to indicate the cauſe of theſe differences. The hardneſs, ſoftneſs, brittleneſs, flexibility, malleability, tranſparency, opacity, and, in a word, all the other obvious qualities, may, for any thing we know, be alike in two bodies, which will nevertheleſs differ greatly in the temperature of their fuſions.

Some chemiſts have aſſerted, that fuſion is ſimply a ſolution in fire, or the matter of heat: but this opinion includes too many yet undecided queſtions to be haſtily adopted. *See* FLUIDITY.

FUSION. The act of fuſing. Alſo the ſtate of a fuſed body.

G.

GAL GAL

GALANGAL. The greater galangal is an Eaſt Indian knotty root, with ſeveral circles on the ſurface, of a reddiſh brown colour on the outſide, and a yellowiſh white within, which greatly reſembles ginger in its ſmell, taſte, and chemical compoſition; but as ginger is the moſt grateful of the two, the galangal is ſcarcely ever uſed.

The ſmaller galangal, which is knotty, and marked with circular ſtriæ like the other, commonly about the ſize of the little finger, and of a brown colour both externally and internally, is in ſmell ſtronger and more agreeable than the large, and in taſte more pungent and hot, like pepper. It contains but a ſmall proportion of oil: ſixteen ounces afforded ſcarcely two ſcruples; though, probably, if conſiderable quantities were diſtilled at once, and the diſtilled water of one operation employed inſtead of freſh water in the next, the yield upon the pound would be greater. The oil is leſs agreeable in ſmell than the galangal itſelf,

and wants its pungency, which of conſequence remains in the extract. Very little of the oil ariſes with rectified ſpirit: the ſpirit diſtilled even from a large quantity of the root has ſcarcely any taſte or ſmell. With regard to the extracts, the watery is rather more pungent than the ſpiritous; but the former have nothing of the peculiar flavour of the galangal, greateſt part of which is retained in the latter. Sixteen ounces yielded with water ſix ounces, and afterwards with ſpirit four drams and two ſcruples: ſpirit applied at firſt extracted an ounce and a half from ſixteen, and water extracted afterwards five ounces. *Neumann.*

GALBANUM exudes from an umbelliferous plant, with leaves like thoſe of aniſe, growing in the Eaſt Indies, but moſt plentifully in Syria and Arabia, called by Tournefort, Oreoſelinum Africanum, Galbaniferum fruteſcens, aniſi folio. This juice comes over in maſſes, compoſed of white, yellowiſh, browniſh yellow, and brown tears, unctuous to the touch, ſoftening betwixt the fingers, of a bitteriſh, ſomewhat acrid, diſagreeable taſte, and a very ſtrong ſmell, generally full of bits of ſtalks, leaves, ſeeds, and other foreign matters.

Galbanum contains more of a reſinous than gummy matter: one pound yields with rectified ſpirit of wine upwards of nine ounces and a half of reſinous extract; but the gummy extract obtained by water from the ſame quantity amounts only to about three ounces. The reſin is hard, brittle, inſipid, and inodorous: the gummy extract has ſomewhat of a nauſeous reliſh, but could not be diſtinguiſhed to be a preparation of galbanum. The whole ſmell, flavour and ſpecific taſte of this juice, reſide in an eſſential oil, which ariſes in diſtillation both with water and ſpirit, and gives a ſtrong impregnation to both: from a pound of galbanum are obtained, by diſtillation with water, ſix drams of actual oil, beſides what is retained by the water. In this reſpect galbanum agrees with aſafœtida, and differs from ammoniacum.

The volatility of the active parts of this juice renders the common method of purifying it, by ſolution, colature, and evaporation, very injurious to it. The ſmell of the galbanum is diffuſed, during the evaporation, over the whole houſe; and the inſpiſſated matter, whatever menſtruum was employed, is found to have loſt the diſtinguiſhing qualities of the original juice. To prevent as much as poſſible this inconvenience, the ſolution ſhould be made in a diſtilling veſſel, and, after filtration, inſpiſſated in the ſame, ſo long at leaſt as the liquor which diſtils has any ſmell or taſte; after which, the galbanum may be reduced to a due conſiſtence, by further evaporation in an open veſſel, and the oil which ariſes in the diſtillation mixed with it. Galbanum may likewiſe be purified ſufficiently for inferior purpoſes, as plaſters, by expoſing it in winter to a ſtrong froſt till it grows hard, and then pulverizing and ſifting it. The woody, ſtrawy, ſtony, and other like matters will be retained in the ſieve.

Galbanum, diſtilled by a ſtrong fire without addition, yields, like other reſinous bodies, a large portion of empyreumatic oil, amounting to upwards of eight ounces upon ſixteen: it is remarkable of the oil of galbanum, that great part of it appears of a blue colour, ſometimes of a deep bright blue, ſometimes of only a violet blue. The matter on which the blueneſs depends, appears to be either very volatile or very changeable: it ſoon eſcapes or changes in the air, leaving, inſtead of the blue, a purple colour.

GALENA, *or* THE BLACK ORE OF LEAD. This, which is the commoneſt of all lead ores, and is frequently diſtinguiſhed by the name of potter's lead ore, is of a dark blueiſh black colour, with a certain degree of metallic luſtre. Its weight is about ſeven or eight times that of water; its figure uſually ſymmetrical, being

either cubical, or a variety of that figure; its texture lamellar, and its hardneſs variable. The component parts of galena are from fifteen to twenty-five ſulphur, from ſixty to eighty-five lead, and a variable quantity of ſilver, ſcarcely ever exceeding two parts in the hundred. Mineralogiſts aſſert, that the ſmall grained galena contains the largeſt portion of ſilver; but it is not worth the extraction, if it do not contain one pound in three thouſand weight. Quartz is accidentally mixed with galena; and it ſometimes contains a very ſmall portion of iron. The reduction of galena may be made by pulverization, torrefaction and fuſion, with three times its weight of black flux. The lead is obtained in a metallic button at the bottom of the crucible; and its weight, compared with that of the ore, ſhews its comparative richneſs.

The humid analyſis of this ore is made by boiling the powder in diluted nitrous acid, which takes up the metallic part, and leaves the ſulphur, the ſtony matrix, and calx of iron, undiſſolved. Digeſtion in marine acid will ſeparate the iron from the reſidue; and cauſtic fixed alkali will diſſolve the ſulphur. The reſiduum, weighed before and after the application of the ſolvents, will ſhew the proportion of each.

The nitrous ſolution will contain the lead and ſilver: this ſolution may be precipitated by the mineral fixed alkali, and the precipitate waſhed in cold water, dried and weighed. After weighing, it muſt again be digeſted in cauſtic volatile alkali, which will diſſolve and take up only the calx of ſilver: the reſiduum being again dried and weighed, gives the proportion of the calx of lead, of which 132 grains are equivalent to 100 in lead in its metallic ſtate; and the difference between the weight of the precipitate, before and after the application of the volatile alkali, gives the quantity of the calx of ſilver, of which 129 grains are equivalent to 100 of ſilver in its metallic form. *See* LEAD.

GALENA, PSEUDO, an ore of zinc, known in the Engliſh mine countries by the name of black jack, or mock lead; its principal ingredients are about half its weight zinc, one third ſulphur, with iron, lead, ſiliceous earth, water, and a ſmall portion of arſenic.

GALL OF ANIMALS. This humour is ſeparated in a large viſcus of the lower belly, called the liver; it is afterwards depoſited in a bladder, or reſervoir, called the gall-bladder, from which it is conveyed into the duodenum by a particular channel.

The bile is glutinous, or imperfectly fluid, like oil; of a very bitter taſte; a green colour inclining to yellow; and froths by agitation, like the ſolution of ſoap.

If it be diſtilled on the water-bath, it affords a phlegm, which is neither acid nor alkaline, but putrefies. This phlegm, according to the obſervation of Mr. de Fourcroy, often emits a ſmell reſembling that of muſk: bile itſelf has the ſame property, according to the general obſervation of butchers. When the bile has given out all the water it is capable of affording upon the water-bath, the reſidue is a dry extract, which attracts the humidity of the air, is tenacious, pitchy, and ſoluble in water. By diſtillation in a retort, it affords ammoniac, an empyreumatic oil, concrete alkali, and inflammable air. The coal is eaſily incinerated. It contains iron, mild mineral alkali, and phoſphorated lime.

All the acids decompoſe bile, and diſengage an oily ſubſtance, which riſes to the top. The ſalts afterwards obtained by evaporation have ſoda for their baſis, which ſhews that the bile is a true animal ſoap. The oil which is combined

with

with ſoda, is analogous to reſins, is ſoluble in ſpirit of wine, &c. The metallic ſolutions decompoſe bile by double affinity, and produce metallic ſoaps.

Bile unites with oils, and cleans ſtuffs in the ſame manner as ſoap.

Bile is ſoluble in alcohol, which ſeparates the albuminous principle. It is the laſt ſubſtance which renders bile coagulable by fire and by acids; and it is this likewiſe which haſtens its putrefaction.

The conſtituent principles of bile are, water, a ſpiritous rector, a lymphatic ſubſtance, a reſinous oil, and ſoda. Mr. Cadet has found a ſalt in it, which he thought ſimilar to ſugar of milk: this ſalt is probably no other than that which was diſcovered by Mr. Poulletier.

Bile is therefore a ſoap, reſulting from the combination of ſoda with a matter of the nature of reſins, and lymphatic ſubſtance, which renders it ſuſceptible of putrefaction and coagulation. This ſubſtance gives the bile the character of animalization, diminiſhes its acridity, and favours its mixture with the other humours. The ſaline part renders the bile more fluid and ſoluble in water; and it is more acrid the more this principle abounds.

The reſinous part differs from vegetable reſins: 1. Becauſe theſe do not form ſoap with fixed alkalis: 2. Becauſe they are more acrid, and more inflammable: 3. Becauſe the animal reſin melts at the temperature of forty degrees, and acquires a fluidity ſimilar to that of fat: from which, however, it differs in being ſoluble in alcohol, in which reſpect it approaches to ſpermaceti.

The acids which act upon bile in the firſt paſſages decompoſe it. The greeniſh yellow colour of the excrements of infants at the breaſt, ariſes from a ſimilar decompoſition; and it is the reſinous part which tinges them. From the action of the bile upon acids, we may deduce the effect of theſe remedies when the evacuations are putrid, and the degeneration of the bile is ſeptic. The lymph is then coagulated, and the excrements become harder. This ſhews the reaſon why the excrements of infants are ſo frequently clotted.

When the bile remains a long time in the firſt paſſages, as, for example, in chronical diſorders, it aſſumes a black colour, becomes thick, acquires the conſiſtence of an unguent, and forms a lining of ſeveral lines in thickneſs in the inteſtinal canal, according to the obſervation of Mr. de Fourcroy. When ſmeared on paper, and dried, it becomes green; diluted with water, it forms a tincture of a yellow green colour, from which a large quantity of black ſcales is precipitated: with alcohol it likewiſe forms a black tincture, and depoſits that luminated brilliant ſalt diſcovered in biliary calculi by Mr. Poulletier de la Salle. This humour, which forms the atra bilis of the ancients, is nothing but the bile rendered thick; and in this caſe the effect of acids, and the danger of irritating ſubſtances, may be eaſily accounted for. This thickening of the bile clogs the viſcera of the lower belly, and produces obſtructions.

Many diſorders are referable to the predominant character of the bile. On this ſubject, the intereſting Memoirs of Mr. de Fourcroy may be conſulted, in the collection of the Royal Society of Medicine for the years 1782 and 1783.

When this bile becomes thick in the gall-bladder, it forms the concretions called biliary calculi.

Mr. Poulletier has paid great attention to the analyſis of the ſtones. He has obſerved that they are ſoluble in ardent ſpirits. When the ſolution is left to itſelf for a certain time, brilliant and light particles are ſeen in it, which Mr. Poulletier found only in the human calculi, and which appeared to him to have the greateſt analogy with the ſalt of benzoin. Mr.

Mr. de Fourcroy has obſerved, that the diſcovery of Mr. de la Salle has been confirmed by the Royal Society (of Medicine), which has received ſeveral biliary calculi that appeared to be formed by a ſalt analogous to that which was obſerved by this chemiſt. They conſiſt of maſſes of tranſparent cryſtalline plates, ſimilar to mica or talc. The Society of Medicine poſſeſſes in its collection a gall-bladder, entirely filled with this ſaline concretion.

We may, therefore, as Mr. de Fourcroy obſerves, admit of two kinds of calculi: the one are opaque, and are afforded only by the condenſed bile; the others conſiſt of the cryſtals we have deſcribed. Boerhaave obſerved long ſince, that the gall-bladder of oxen, at the end of the winter, was filled with calculi; but that the freſh paſturage diſſipated theſe concretions.

Soaps have been propoſed as ſolvents for theſe calculi. The Academy of Dijon has publiſhed the ſucceſs of a mixture of eſſence of turpentine and ether. Freſh vegetables, which are ſuch ſovereign remedies in deſtroying theſe concretions, owe their virtue, perhaps, to the circumſtance that they develop an acid in the ſtomach, as we have obſerved in the treating of the gaſtric juice.

The uſe of the bile in the animal œconomy conſiſts, no doubt, in dividing thoſe ſubſtances which have undergone a firſt digeſtion in the ſtomach, and in giving efficacy and force to the motions of the inteſtines. When its flux is interrupted, it abounds in the blood, and the whole body becomes of a yellow tinge.

The bile or gall is an excellent vulnerary, externally applied: internally taken, it is a good ſtomachic, and one of the beſt deobſtruents the art of medicine poſſeſſes. This kind of remedies deſerves the preference, as being more analogous to the conſtitution; and bile is a proper medicine when the digeſtion languiſhes, or the viſcera of the lower belly are clogged.

Bile, like other ſoaps, removes ſpots of oil, or other greaſy matter, from ſubſtances to which they are adherent.

GALLS. *See* ACID OF GALLS.

GALLEY. An oblong reverberatory furnace, in which a row of retorts is placed beſide each other, with their necks protruding through lateral openings.

GAMBOGE is a concrete vegetable juice, the produce of two trees, both called by the Indians caracapulli (gambogia gutta Lin.), and is partly of a gummy and partly of a reſinous nature. It is brought to us either in form of orbicular maſſes, or of cylindrical rolls of various ſizes; and is of a denſe, compact and firm texture, and of a beautiful yellow. It is chiefly brought to us from Cambaja, in the Eaſt Indies, called alſo Cambodja, and Cambogia; and from thence it has obtained its name of cambadium, cambogium, and gambogium.

It is a very rough and ſtrong purge: it operates both by vomit and ſtool, and both ways with much violence, almoſt in the inſtant in which it is ſwallowed, but yet, as it is ſaid, without griping. The doſe is from two to four grains as a cathartic; from four to eight grains prove emetic and purgative. The roughneſs of its operation is diminiſhed by giving it in a liquid form ſufficiently diluted.

This gum reſin is ſoluble both in water and in ardent ſpirit. Alkaline ſolutions poſſeſs a deep red colour, and paſs the filter. Dr. Lewis informs us, that it gives a beautiful and durable citron yellow ſtain to marble, whether rubbed in ſubſtance on the hot ſtone, or applied as dragon's blood; ſometimes is in form

of

of a ſpiritous tincture. When it is applied on cold marble, the ſtone is afterwards to be heated to make the colour penetrate.

It is chiefly uſed as a pigment.

GANGUE. The ſtones which fill the cavities that form the veins of metals are called the gangue, or matrix of the ore; the rocks that lie over the veins are called the roof; thoſe that lie under them the floor, and by ſome the hading: the matrix is almoſt always a finer ſpecies of ſtone than the ſurrounding rocks, though of the ſame genus; even the rocks themſelves are finer grained as they approach the vein.

There is no matrix peculiarly appropriated to any metal; it has only been remarked, that tin is generally found among ſtones of the ſiliceous genus, and lead very frequently among thoſe of the calcareous.

GARNET, a ſtone, which, when tranſparent and of a fine colour, is reckoned among gems. Its colour is blueiſh or yellowiſh red; its tranſparency often obſcure, unleſs it be held to a ſtrong light. The natural form of its cryſtals is various, and ſeldom regular. Its texture is granular. The ſpecific gravity of the garnet, according to various authors, is from 3,6 to 4,4. Its hardneſs is nearly the ſame as that of the emerald, being leſs hard than the topaz, and more ſo than rock cryſtal.

A ſtrong calcining heat does not deprive it of its colour. A very conſiderable heat is required to fuſe it without addition, when it takes the form of a black ſlag, obedient to the magnet. Mineral alkali does not attack it ſo powerfully as borax or microcoſmic ſalt.

According to the analyſis of Achard, the garnet contains 48,3 of ſiliceous earth, 30 of clay, 11,6 of lime, and 10 of iron. The opaque garnets ſcarcely give fire with ſteel, and afford about 20 per cent. of iron. Bergman informs us, that they contain tin, and even lead, though very rarely.

The garnet is a very common ſtone, frequently embodied in the maſſes of compound rocks. The Syrian garnet, which is of a fine red, inclining to purple, and very clear, though leſs brilliant than the oriental amethyſt, is the moſt eſteemed.

GAS. This term was firſt applied by Van Helmont, to denote the permanently elaſtic exhalations afforded in chemical proceſſes. Dr. Prieſtley, whoſe extenſive and ſucceſsful reſearches into this department of natural philoſophy have, in the ſpace of a few years, produced a revolution in the ſcience of chemiſtry, uſes the word air as the generic term for permanently elaſtic fluids. Other chemical writers of great reputation have thought fit to revive Van Helmont's term, and confine the word air to the atmoſpheric fluid. The Engliſh philoſophers, however, have in general followed Dr. Prieſtley; and as it ſeems altogether as ſimple, to add the word atmoſpherical, vital, or reſpirable, to that air which is peculiarly adapted to the maintenance of life and combuſtion, as to denote it by any ſingle peculiar term not uſed in the enunciation of other elaſtic fluids, we have alſo adopted the ſame rule. *See* AIR.

GASTRIC JUICE. That humour which is known by the name of the gaſtric juice, is ſeparated by glands placed between the membranes which line the ſtomach; and from theſe it is emitted into the ſtomach itſelf.

In order to obtain the gaſtric juice in a ſtate of purity, the animals intended to furniſh it are kept faſting for two days, after which the ſtomach is extracted. In this manner Spallanzani obtained thirty-ſeven ounces of this juice out of the two

firſt

firſt ſtomachs of a ſheep. The ſame naturaliſt cauſed animals to ſwallow thin tubes of metal, pierced with ſeveral holes, into which he had put ſmall ſponges, very clean and dry. He cauſed crows to ſwallow eight at a time, which were vomited up at the end of three hours and a half. The juice which he obtained was yellow, tranſparent, ſalt, bitter, and leaving very little ſediment, when the bird was faſting. The gaſtric juice may likewiſe be procured by the vomiting which is excited by irritation during faſting. M. Scopoli has obſerved, that the moſt fluid part is only thrown up by irritation; and that the thicker part does not quit the ſtomach, but by the aſſiſtance of an emetic. M. Goſſe, who had long accuſtomed himſelf to ſwallow the air, which anſwered the purpoſe of an emetic with him, has availed himſelf of this habit to make ſome experiments with the gaſtric juice. He ſuſpends his reſpiration, receives air into his mouth, and puſhes it towards the pharinx with his tongue. This air, rarefied in his ſtomach, produces a convulſive motion, which clears it of its contents. Spallanzani has obſerved, the eagles ſpontaneouſly emit a conſiderable quantity of gaſtric juice, when faſting in the morning.

We are indebted to Reaumur, and the Abbé Spallanzani, for very intereſting experiments reſpecting the virtue and effects of the gaſtric juice in digeſtion. They cauſed animals to ſwallow tubes of metal, perforated in various places, and filled with aliments, to examine their effects. The philoſopher of Pavia uſed purſes of thread, and bags of linen and woollen. He himſelf ſwallowed ſmall purſes filled with fleſh boiled or raw, with bread maſticated, and alſo in its original ſtate, &c.; and likewiſe ſmall cylinders of wood, five lines in length, and three in diameter, pierced with holes, and covered with cloth.

M. Goſſe, availing himſelf of the facility with which he was able to vomit by means of the air, has taken all kinds of food, and examined the changes they had undergone, by returning them after intervals more or leſs remote from the time of deglutition.

From theſe various experiments it follows,

1. That the gaſtric juice reduces the aliments into an uniform magma, even out of the body, and in vitro; and that it acts in the ſame manner on the ſtomach after death: which proves that its effect is chemical, and almoſt independent of vitality. 2. That the gaſtric juice effects the ſolution of the aliments included in tubes of metal, and conſequently defended from any trituration. 3. That though there is no trituration in membraneous ſtomachs, this action powerfully aſſiſts the effect of the digeſtive juices in animals whoſe ſtomach is muſcular, ſuch as ducks, geeſe, pigeons, &c. Some of theſe animals, bred up with ſufficient care that they might not ſwallow ſtones, have nevertheleſs broken ſpheres and tubes of metal, blunted lancets, and rounded pieces of glaſs, which were introduced into their ſtomachs. M. Spallanzani has aſcertained, that fleſh included in ſpheres ſufficiently ſtrong to reſiſt the muſcular action, was completely digeſted. 4. That gaſtric juice acts by its ſolvent power, and not as a ferment; becauſe the ordinary and natural digeſtion is attended with no diſengagement of air nor inflation, nor heat, nor, in a word, with any other of the phenomena of fermentation.

M. Scopoli obſerves very well, that nothing poſitive or certain can be aſſerted reſpecting the nature of the gaſtric juice. It is ſometimes acid, and ſometimes inſipid. M. Brugnatelli has found in the gaſtric juice of carnivorous birds, and ſome others, a diſengaged acid, a reſin and animal ſubſtance, united with a ſmall

quantity of common ſalt. The gaſtric juice of ruminating animals contains ammoniac, an extractive animal ſubſtance, and common ſalt. In our time the phoſphoric ſalts have been found diſengaged in the gaſtric juice.

It appears from the obſervations of Meſſrs. Spallanzani and Goſſe, that the nature of the gaſtric juice varies according to that of the aliments. This juice is conſtantly acid when the diet is vegetable. The Abbé Spallanzani affirms, contrary to Meſſrs. Brugnatelli and Carminati, that birds of prey have never afforded him an acid juice; and he affirms the ſame of ſerpents, frogs, fiſhes, &c.

In order to ſhew clearly that there is a great difference between the gaſtric juices of various animals, it is ſufficient to obſerve, that the gaſtric juice of the kite, the falcon, &c. does not diſſolve bread, though it digeſts fleſh meat; and that the gaſtric juice of the turkey, the duck, &c. has no action upon fleſh, but converts the hardeſt grain into a pulp.

Meſſrs. Jurine, Toggia, and Carminati, have made the moſt ſucceſsful applications of the gaſtric juice in the treatment of wounds.

GEANTHRAX. *See* PEAT.

GELATINOUS MATTER, or

GELLY, or JELLY, an animal ſubſtance, ſoluble in water, but not in ardent ſpirit, capable of aſſuming a well-known elaſtic or tremulous conſiſtence by cooling when the water is not too abundant, and liquefiable again by increaſing its temperature. This laſt property remarkably diſtinguiſhes it from ſerum and white of egg, which become conſiſtent by heat.

Jellies are very common in our kitchens: they may be extracted from all the parts of animals, by boiling them in water. Hot water diſſolves a large quantity of this ſubſtance. Acids likewiſe diſſolve them, as do likewiſe more particularly the alkalis. Jelly which has been extracted without long decoction, poſſeſſes moſt of the characters of vegetable mucilage; but it is ſeldom obtained without a mixture of ſerum.

Jellies in a pure ſtate have ſcarcely any ſmell or remarkable taſte. By diſtillation they afford an inſipid and inodorous phlegm, which eaſily putrefies. A ſtronger heat cauſes them to ſwell up, become black, and emit a fœtid odour, accompanied with white acrid fumes. An impure volatile alkali, together with empyreumatic oil, then paſſes over, leaving a ſpungy coal, not eaſily burned, and containing common ſalt and phoſphorated lime.

The nitrous acid diſengages phlogiſticated air from jellies.

The jelly of various animal ſubſtances is prepared for the uſe of ſea-faring perſons, under the name of portable ſoup. The whole art of performing this operation conſiſts in boiling the meat, and taking the ſcum off, as uſual, until the ſoup poſſeſſes the requiſite flavour. It is then ſuffered to cool, in order that the fat may be ſeparated. In the next place, it is mixed with five or ſix whites of eggs, and ſlightly boiled. This operation ſerves to clarify the liquid, by the removal of opake particles, which unite with the white of egg at the time it becomes ſolid by the heat, and are conſequently removed along with it. The liquor is then to be ſtrained through flannel, and evaporated on the water bath to the conſiſtence of a very thick paſte; after which it is ſpread rather thin upon a ſmooth ſtone, then cut into cakes, and, laſtly, dried in a ſtove until it becomes brittle. Theſe cakes may be kept four or five years, if defended from moiſture. When intended to be uſed, nothing more is required to be done than to diſſolve a ſufficient quantity in boiling water, which by that means becomes converted into ſoup. *See* GLUE.

GEMS,

GEMS. This word is uſed to denote ſuch ſtones as are conſidered by mankind as precious. Theſe are the diamond, the ruby, the ſapphire, the topaz, the chryſalite, the beryl, the emerald, the hyacinth, the amethyſt, the garnet, the tourmalin, the opal; and to theſe may be added, rock cryſtal, the finer flints or pebbles, the cat's eye, the oculus mundi, or hydrophanes, the chalcedony, the moon-ſtone, the onyx, the cornelian, the ſardonyx, agates, and the Labrador-ſtone; for which, conſult the ſeveral articles reſpectively.

GILDING. The art of covering the ſurfaces of bodies with gold. Manufacturers uſe the term improperly to denote ſilvering as well as gilding, and likewiſe the various methods of producing a golden colour without actually uſing gold.

The real application of gold as a covering may be performed, either by a metallic mixture after the manner of a pigment; or by friction, upon the ſame principle as black lead and coloured chalks are uſed; or by the chemical precipitation of gold from mercury, or ſome other fit ſolvent; or, laſtly, by glueing or faſtening extremely thin leaves of gold to the ſurface intended to be gilded.

The gold prepared for painting is called ſhell-gold or gold-powder, and may be obtained by amalgamating one part of gold with eight of quickſilver, and afterwards evaporating the latter, which leaves the gold in the form of powder; or otherwiſe the metal may be reduced to powder by mechanical trituration. For this purpoſe, gold-leaf muſt be ground with honey or ſtrong gum-water for a long time; and when the powder is ſufficiently fine, the honey or gum may be waſhed off with water.

For cold gilding by friction, a fine linen rag is ſteeped in a ſaturated ſolution of gold, till it has entirely imbibed the liquor; this rag is then dried over a fire, and afterwards burned to tinder. Now, when any thing is to be gilded, it muſt be previouſly well burniſhed: a piece of cork is then to be dipped, firſt into a ſolution of ſalt in water, and afterwards into the black powder; and the piece, after it is burniſhed, rubbed with it.

The chemical application of gold to the ſurface of metals is uſually called water-gilding, a term probably at firſt confined to ſuch proceſſes as demand the uſe of a ſolution of gold in aqua regia. If this ſolution be copiouſly diluted with ardent ſpirit, a piece of clean iron will be gilded by being ſteeped therein. For the method called Grecian gilding, equal parts of ſal ammoniac and corroſive ſublimate are diſſolved in nitrous acid, and a ſolution of gold is made in this menſtruum; upon this the ſolution is ſomewhat concentrated, and applied to the ſurface of ſilver, which becomes quite black; but, on being expoſed to a red heat, it aſſumes the appearance of gilding.

The method of gilding ſilver, braſs, or copper, by an amalgam, is as follows: Eight parts of mercury, and one of gold, are incorporated together by heating them in a crucible. As ſoon as the gold is perfectly diſſolved, the mixture is poured into cold water, and is then ready for uſe.

Before the amalgam can be laid upon the ſurface of the metal, this laſt is bruſhed over with dilute aqua fortis, in which it is of advantage that ſome mercury may have been diſſolved. Some artiſts then waſh the metal in fair water, and ſcour it a little with fine ſand, previous to the application of the gold; but others apply it to the metal while ſtill wet with the aqua fortis. But in either caſe the amalgam muſt be laid on as uniformly as poſſible, and ſpread very evenly with a braſs-wire bruſh, wetted from time to time with fair water. The piece is

then laid upon a grate, over a charcoal fire, or in a ſmall oven or furnace adapted to this purpoſe. The heat drives off the mercury, and leaves the gold behind. Its defects are then ſeen, and may be remedied by ſucceſſive applications of more amalgam, and additional application of heat. The expert artiſts, however, make theſe additional applications while the piece remains in the furnace, though the practice is ſaid to be highly noxious on account of the mercurial fumes. After this it is rubbed with gilders wax, which may conſiſt of four ounces of bees wax, one ounce of verdigriſe, and one ounce of blue vitriol: then expoſe it to a red heat, which burns off the wax; and laſtly, the work is cleared with the ſcratch bruſh, and burniſhed, if neceſſary, with a ſteel tool. The uſe of the wax ſeems to conſiſt merely in covering defects, by the diffuſion of a quantity of red calx of copper, which is left behind after the burning.

The gilding of iron by mere heat is performed by cleaning and poliſhing its ſurface, and then heating it till it has acquired a blue colour. When this has been done, the firſt layer of gold leaf is put on, ſlightly burniſhed down, and expoſed to a gentle fire. It is uſual to give three ſuch layers, or four at the moſt, each conſiſting of a ſingle leaf for common works, or two for extraordinary ones. The heating is repeated at each layer, and laſt of all the work is burniſhed.

Painting with gold upon porcelain or glaſs is done with the powder of gold, which remains behind after diſtilling the aqua regia from a ſolution of that metal. It is laid on with borax and gum water, burned in, and poliſhed. The gilding of glaſs is commonly effected by covering the part with a ſolution of borax, and applying gold leaf upon it, which is afterwards fixed by burning.

The gilders of wood and other compoſitions deſigned to ſupply the place of carved work, make uſe of two methods: the one called oil-gilding, or gilding in oil, becauſe the gold is made to adhere by means of an oily compoſition; the other is ſometimes called water-gilding, though ſeldom, but more frequently burniſhed gold, on account of the burniſh it is capable of, which is one of the principal advantages it poſſeſſes over the other method.

Gilding in oil is performed by means of a paint ſold under the name of gold ſize. It conſiſts of drying oil (that is to ſay, linſeed oil boiled upon litharge), and mixed with yellow ochre. It is ſaid to improve in its quality by keeping. This is laid upon the work; and when it has become ſo dry as to adhere to the fingers without ſoiling them, the gold leaf is laid on, and preſſed down with cotton. This method of gilding is proper for work intended to be expoſed to the weather.

The method of gilding in burniſhed gold conſiſts in covering the work with parchment ſize and whiting, thinly laid on at five or ſix different times. This is covered with a yellow ſize made of Armenian bole, a little wax, and ſome parchment ſize; but in this, as in moſt other compoſitions uſed in the arts, there are variations which depend on the ſkill or the caprice of the artiſts. When the ſize is dry, the gold is applied upon the ſurface previouſly wetted with clear water. A certain number of hours after this application, but previous to the perfect hardening of the compoſition, the gold may be very highly burniſhed with a tool of agate made for that purpoſe. This gilding is fit only for work within doors; for it readily comes off upon being wetted.

The edges of the leaves of books are gilded by applying a compoſition of one part Armenian bole, and one quarter of a part ſugarcandy, ground together with white of eggs. This is burniſhed while the book remains in the preſs, and the gold is laid on by means of a little water.

Leather

Leather is gilded either with leaf-braſs or ſilver, but moſt commonly by the latter, in which caſe a gold-coloured varniſh is laid over the metal. Tin-foil may be uſed inſtead of ſilver-leaf for this leſs perfect gilding, upon ſuch works as do not poſſeſs flexibility.

GINGER, is the produce both of the Eaſt and the Weſt Indies. Two ſorts of this root are brought to us, one internally white, the other brown: whether they are the roots of different ſpecies of the ginger plant, or of one ſpecies taken up at different ages, or in different ſeaſons, is not certainly known. This pungent aromatic is of common uſe as a ſpice, and is obſerved not to heat the conſtitution near ſo much as might be expected from its ſtrong biting taſte. Its pungency reſides not in its volatile, but in its fixed parts: the eſſential oil contains the ſmell and diſtinguiſhing flavour of the ginger, but all the pungency is left behind in the ſtill.

From ſixteen ounces of the common brown ginger may be obtained a dram or a little more of oil. The ſame quantity yielded, with rectified ſpirit, an ounce and two ſcruples of reſinous extract, containing all the hot biting matter of the root: from the reſiduum, water extracted a ſtrong mucilage, which had little or no taſte, was difficultly reduced to dryneſs, and weighed, when exſiccated, five drams and a half. Sixteen ounces, treated firſt with water, gave four ounces of extract, conſiderably pungent, a portion of the reſinous matter being taken up by the water along with the gummy: from the reſiduum, ſpirit extracted five ſcruples four grains of a very pungent reſin. The indiſſoluble earthy matter amounts to near three-fourths of the root, viz. eleven ounces ſix drams and ſixteen grains. Rectified ſpirit elevates in diſtillation ſome of the more ſubtile parts of the oil, ſo as to taſte a little of the ginger, though not conſiderably.

The white ginger contains more ſoluble matter than the brown. From ſixteen ounces of this ſort were gained five ounces five drams and a ſcruple of watery, and afterwards three drams twelve grains of ſpiritous extract. Spirit applied at firſt, extracted one ounce and three drams wanting a few grains; and water applied afterwards, took up four ounces and a half: ſo that the indiſſoluble part does not amount quite to ten ounces on ſixteen. The quantity of eſſential oil is nearly the ſame as in the brown ſort. *Neumann.*

GINSENG. Panax quinquefolium Lin. A ſmall root brought from North America, and ſometimes from China; an inch or two in length, taper, finely ſtriated, of a whitiſh or yellowiſh colour. It has a very ſweet taſte, accompanied with a ſlight bitteriſhneſs and warmth.

The Chineſe are ſaid to have a very extraordinary opinion of the virtues of this root, and to look upon it as an univerſal reſtorative in all decays, from age, intemperance, or diſeaſe. The great value there ſet upon it has prevented its being exported from thence into other countries, and its diſcovery in North America is but of late date; ſo that among us it has hitherto been very rarely made uſe of, although, from what can be judged of it from the taſte, it ſeems to deſerve ſome regard, eſpecially as it is now procurable in plenty.

The American ginſeng appears opake and white when broken; and though it produces a good price in the Chineſe market, yet it is vaſtly leſs valuable than the ginſeng of Chineſe growth, which is nearly as tranſparent as horn. This property ſeems to have been produced by art, perhaps by long-continued and gentle boiling in water.

GIRASOLE, a name given by the Italians to the opal, which is of the flint

kind, and remarkable for the mutability of its colours, according to the various directions of the light which falls on it, and the poſition of the eye of the obſerver.

GLACIES MARIÆ. A name given to the clear tranſparent gypſum, or vitriolated lime. It is ſeldom uſed.

GLASS. The vitriform ſtate is that of an incombuſtible body, which has been fuſed by a red heat. All ſubſtances, therefore, of ſufficient fixity to ſuffer ignition, and ſufficient fuſibility to be rendered fluid by the greateſt temperatures we are capable of producing, may be converted into glaſs. The metals, though fixed enough to ſuſtain ignition, and fuſible under that temperature, are not converted into glaſs until they have paſſed through the proceſs of calcination or combuſtion.

It is probable that all ſubſtances which do not riſe into the atmoſphere by heat, nor combine with it in combuſtion, are in their own nature vitrifiable, that is to ſay, fuſible; and that the differences between bodies in this reſpect are merely relative to our power of producing heat. We ſhall not however inſiſt more fully upon this extended view of the ſubject, but ſhall proceed to conſider glaſs as a body more or leſs tranſparent, very hard, brittle, fuſible in a ſtrong heat, artificially prepared by fire electric, by friction, and ſcarcely, if at all, affected by the action of air, water, ardent ſpirit, oil, or the major part of ſaline ſubſtances.

When, or by whom, the art of making glaſs was firſt found out, is uncertain: ſome will have it invented before the flood; but without any proof. Neri traces the antiquity of this art as far back as the time of Job: but Dr. Merret will have it as ancient as either pottery, or the making of bricks; becauſe, that a kiln of bricks can ſcarce be burnt, or a batch of pottery be made, but ſome of the bricks and the ware will be at leaſt ſuperficially turned to glaſs; ſo that it muſt have been known at the building of Babel, and as long before as the making of bricks was uſed. It muſt have been known conſequently among the Egyptians, when the Iſraelites were employed by them in making bricks. Of this kind, no doubt, was that foſſil glaſs mentioned by Ferrant. Imperat. to be found under ground where great fires had been. The Egyptians indeed boaſt, that this art was taught them by the great Hermes. Ariſtophanes, Ariſtotle, Alexander Aphrodiſæus, Lucretius, and John the divine, put us out of all doubt that glaſs was uſed in their days.

Moſt of the glaſſes made for direct uſe, conſiſt of an earthy ſubſtance called the baſis, and a ſaline or metallic ſubſtance called the flux. The baſis is uſually ſiliceous earth, the ſalt an alkali, and the metal lead. But various admixtures of earth and metallic calces are uſed in the actual practice of the art. None of the acids, except the phoſphoric, are ſufficiently fixed to withſtand the heat required to form the vitreous combination with an earth; and this ſalt has not yet been afforded cheap enough to be uſed except in aſſays by the blow-pipe. The fluxes in glaſs-making are uſeful, not only becauſe more fuſible than the earthy matter, to which they communicate the ſame property, but likewiſe as ſolvents which combine with it in the dry way, and in ſome inſtances produce a compound poſſeſſing greater fuſibility than belonged to any of the ingredients. *See* CALCAREOUS EARTH, p. 301.

The earthy ſubſtances made uſe of in the compoſition of glaſs are, quartzoſe, ſand, flint, gypſeous ſpar, chalk, and the like, either ſingly or in various proportions; except, however, that the ſiliceous earth is not to be diſpenſed with.

The

The ſaline additions conſiſt either of barilla or ſoda, common pot-aſh, or wood-aſhes, and amount to about one-third part of the whole. Theſe ſubſtances are purified and pounded with greater or leſs care, according to the excellence of the glaſs intended to be produced. If the materials were put into a veſſel and expoſed to fuſion, they would froth and ſwell much, partly on account of the eſcape of moiſture and other volatile matter, and partly by reaſon of ſome elaſtic fluid which appears to be extricated at the time of the combination of the baſis and the flux. Various impurities of an inflammable nature would likewiſe remain unconſumed in the body of the glaſs, and injure its colour. To prevent theſe inconveniences, the compoſition is kept for the ſpace of four and twenty hours in a furnace of a particular conſtruction, at a degree of heat not ſufficient to produce complete fuſion, and with acceſs of air. It is repeatedly ſtirred during this calcination, and becomes at length converted into an imperfect glaſs called fritt. This is put into the melting-pots, and fuſed by the ſtrong heat of a reverberatory furnace. The fuſed glaſs has the property of ſticking to an iron rod or tube, by which means it is taken out, either to aſcertain a ſtate of perfection, or to blow it into ſuch utenſils as may be wanted. The unvitrifiable ſalts, or ſuch as do not enter into combination with the earth, ſwim at the top of the veſſel, forming the ſubſtance called ſandiver, or glaſs gall, which muſt be ſcummed off.

Neri's Art of Glaſs-Making, and other books, may be conſulted for a deſcription of the mechanical part and utenſils of this art. In general, the glaſs is taken out by dipping an iron tube into the pot, and the quantity to be uſed at once, is regulated by a proceſs ſomewhat reſembling that of the tallow-chandlers; that is to ſay, the part firſt dipped out is ſuffered to cool a little, and ſerves as the receptacle for more glaſs to be taken up at a ſecond dip, and ſo forth until the quantity is ſufficient. The lump of glaſs may be ſoftened at pleaſure, by holding it before the mouth of the furnace. The workman renders it hollow, and of a ſpherical form, by blowing through the tube. This ſphere may be converted into a cone, a cylinder, or any other ſolid, whoſe tranſverſe ſection is a circle, by rolling it on a flat plate of iron. It may be ſtretched in length by ſwinging the tube in the air, or giving it a vibratory motion like that of a pendulum. The workmen ſhew great dexterity in heating the glaſs in the various ſtages of the manipulation. They do this in ſuch parts as they are deſirous of extending; and on other occaſions they cool certain parts of their work, by fanning the air againſt it. The glaſs, in the ignited ſtate it poſſeſſes after it comes out of the pots, is very tough and flexible, may be cut with ſhears, bended with pincers, preſſed into moulds, and wrought in a variety of methods dependent on theſe properties, of which the artiſts very dexterouſly avail themſelves.

As far as obſervation has hitherto directed us, it appears to be a general rule, that the hardneſs, brittleneſs, elaſticity, and other mechanical properties of congealed bodies, are greatly affected by the degree of rapidity with which they aſſume the ſolid ſtate. This, which no doubt is referrible to the property of cryſtalliſation, and its various modes, is remarkably ſeen in ſteel and other metals, and ſeems to obtain in glaſs. When a drop of glaſs is ſuffered to fall into water, it is found to poſſeſs the remarkable property of flying into minute pieces, the inſtant a ſmall part of the tail is broken off. This, which is commonly diſtinguiſhed by the name of Prince Rupert's drop, is ſimilar to the philoſophical phial, which is a ſmall veſſel of thick glaſs ſuddenly cooled by expoſure to the air. It poſſeſſes the property of flying in pieces when the ſmalleſt piece of flint or angular pebble

is let fall into it. Many explanations have been offered to account for theſe and other ſimilar appearances, by referring to a ſuppoſed mechaniſm or arrangement of the particles, or ſudden confinement of the matter of heat. The immediate cauſe however appears to be derived from the fact, that the dimenſions of bodies ſuddenly cooled, remain larger than if the refrigeration had been more gradual. Thus the ſpecific gravity of ſteel hardened by ſudden cooling in water is leſs, and its dimenſions conſequently greater, than that of the ſame ſteel gradually cooled. It is more than probable that an effect of the ſame nature obtains in glaſs; ſo that the dimenſions of the external and ſuddenly cooled ſurface remain larger than are ſuited to the accurate envelopment of the interior part, which is leſs ſlowly cooled. In moſt of the metals, the degree of flexibility they poſſeſs, muſt be ſufficient to remedy this inaccuracy as it takes place; but in glaſs, which, though very elaſtic and flexible, is likewiſe exceſſively brittle, the adaptation of the parts, urged different ways by their diſpoſition to retain their reſpective dimenſions, and likewiſe to remain in contact by virtue of the coheſive attraction, can be maintained only by an elaſtic yielding of the whole, as far as may be, which will therefore remain in a ſtate of tenſion. It is not therefore to be wondered at, that a ſolution of continuity of any part of the ſurface ſhould deſtroy this equilibrium of elaſticity; and that the ſudden action of all the parts at once, of ſo brittle a material, ſhould deſtroy the continuity of the whole, inſtead of producing an equilibrium of any other kind.

Though the facts relating to this diſpoſition of glaſs too ſuddenly cooled are numerous and intereſting to the philoſopher, yet they conſtitute a ſerious evil with reſpect to the uſes of this excellent material. The remedy of the glaſs-maker conſiſts in annealing the ſeveral articles, which is done by placing them in a furnace above the furnace of fuſion. The glaſſes are firſt put into the hotteſt part of this furnace, and gradually removed to the cooler parts at regular intervals of time. By this means the glaſs cools very ſlowly throughout, and is in a great meaſure free from the defects of glaſs which has been too haſtily cooled.

It is difficult to ſpeak with any preciſion concerning the materials, proportion, and management neceſſary to make the different kinds of glaſs, ſuch as the green glaſs for bottles, the greeniſh or blueiſh glaſs for windows, the white glaſs for mirrors, the white flint glaſs for bottles, and the cryſtal glaſs uſed for the finer wares, called cut glaſs, not to mention the denſe white glaſs made expreſsly for optical uſes. All theſe are made of better quality at ſome manufactories than at others; and it is probable that this ſuperiority of produce is thus confined by the natural diſpoſition for ſecrecy which prevails among men, whoſe pecuniary ſucceſs in a great meaſure depends on their monopolizing the effects of their own ſkill. Far be it from me to pretend to conſider this proceeding as immoral. On the contrary, I very much doubt whether any ſpecies of property can be defended under a title in any reſpect ſo ſtrong as that which a man muſt hold in his own ſuperiority of intellect and exertion. I mean ſimply to obſerve in this place, that, from the cauſes here mentioned, it is impoſſible to give a minute account of the art. The green glaſs is made from impure materials; the baſis conſiſting of a ferruginous ſtone or ſand, and the alkali being ſuch as can be the moſt cheaply purchaſed. The colour chiefly depends on the iron; and the glaſs is harder, more durable, and leſs deſtructible by acids remaining in it for a long time, the leſs the quantity of alkali, and conſequently the greater the heat. Pit coal is uſed as fuel in the Engliſh glaſs-houſes. It produces a more intenſe heat than wood.

Chaptal,

Chaptal, in his Elements of Chemiſtry, mentions the ſucceſsful eſtabliſhment of a manufactory of opaque bottles of exceſſive ſtrength and lightneſs, compoſed chiefly of baſaltes; but he relates that the eſtabliſhment failed, chiefly on account of the quality of the baſaltes, which did not conſtantly prove the ſame, but, becoming in the latter ſtages of the undertaking more calcareous, produced an article of a periſhable nature.

All the white glaſſes owe their clearneſs to the purity of the materials. The fineſt ſiliceous ſand is fuſed with purified alkali. The calces of lead act as a powerful flux, and are much uſed in compoſitions of this nature. They give denſity, ſoftneſs, and a diſpoſition to take a brilliant poliſh.

Optical writers teach us, that the refracting teleſcope conſiſts of a convex lens, called the object lens, in the focus of which the image of a remote object is formed; and that this image is ſeen magnified and diſtinct by a microſcope applied to it, which forms the apparatus at the other end of the teleſcope. It may eaſily be imagined, that if the focal image be indiſtinct, or if there be a number of focal images occupying different parts of the field of view of the teleſcope, the effect will be leſs perfect, and the magnifying power muſt be leſs, in order that the confuſion may be at all tolerable. Whenever a ray of white or compounded light is refracted out of its courſe, by paſſing into another ſimple medium of different denſity from that through which it originally paſſed, it is found to be ſeparated into its component parts, which produce the ſenſations of various colours. This ſeparation is made by virtue of the different properties poſſeſſed by the ſeveral rays of light, by which ſome are more refracted in like circumſtances than others. Thus the blue is more refracted than the green and yellow, and theſe are more refracted than the red rays. Whence it follows that a pencil of white light, which paſſed in parallel rays to a wedge or priſm of glaſs, will come out of the priſm on the other ſide, not only refracted in the whole, but differently refracted as to its parts; the red being leſs turned out of its courſe than any of the other rays, and the violet being the moſt deflected of any. And this difference of direction will be greater, the greater the mean refraction. The edges of a convex lens may be conſidered as wedges of the ſame nature, with regard to the light, as the priſm here mentioned. Such a lens, refracting the red rays leſs than any other, will form a red image at a certain focal diſtance. The yellow rays, being ſomewhat more refracted, will afford a yellow image, at a diſtance leſs remote from the lens; and, for ſimilar reaſons, there will be formed, at ſtill nearer diſtances, images of green, blue and violet, with all the intermediate ſhades of colour. The entire focal image will conſiſt of all theſe images irregularly combined. It has been diſcovered, that the quantity of diſperſion is greater in ſome kinds of glaſs than in others, while the mean refraction or focal length remains the ſame. Two priſms of ſuch different kinds of glaſs, producing the ſame mean refraction towards contrary parts on a ray of light, would not therefore correct the colorific diſperſion, though the ray would proceed onward nearly in its original direction. It would be neceſſary, in order that this diſperſion produced by the one glaſs ſhould be accurately corrected by the other, that the mean refraction ſhould be greateſt in that which poſſeſſed the leaſt power in diſperſing the rays of light; and, in this caſe, the colourleſs emergent ray would not proceed in its firſt direction. To apply this doctrine to teleſcopes—Suppoſe a convex lens formed of ſuch glaſs as afforded very little colorific diſperſion of the rays, and a concave lens of ſuch glaſs as afforded much of this effect: it will follow, that when theſe

two lenſes poſſeſs ſuch a figure as that the concave ſhall deſtroy the priſmatic colours produced by the convex, the exceſs of mean refraction muſt be in the latter; and conſequently, that the compound glaſs will act like a convex lens, and produce a real colourleſs focal image.

The problem of conſtructing teleſcopes which ſhall be truly achromatic, depends, as we have before obſerved, chiefly on the perfection to which the glaſſes can be brought. The general facts reſpecting glaſſes for this uſe are, that lead, and probably other metallic calces, increaſe the diſperſive power more than alkalis, and theſe laſt more than earthy fluxes; and that an addition of alkali to glaſſes containing lead, ſerves greatly to diminiſh the mean refraction, without much affecting the diſperſive power occaſioned by the metal. Hence it might ſeem eaſy to compoſe ſuch glaſs as the theorems of the optician demand; but the practice is by no means ſo ready. Regular refraction demands that the medium ſhould poſſeſs an uniform denſity throughout, or, in other words, that the parts of the glaſs ſhould be well combined together. This however is ſeldom the caſe, eſpecially in the denſe metallic glaſs. It is found, that the great fuſibility of the glaſs of lead cauſes it to flow, and occupy the interſtices between the particles of the ſand before theſe are melted. So that ſome very bright and apparently homogeneous glaſſes exhibit an infinity of ſmall focal images of a candle, when examined by a magnifier, which are produced by rounded particles of ſand remaining in every part of the ſubſtance. Another fault, ſtill more common, conſiſts in veins of a different denſity from the reſt, partly ariſing from imperfect fuſion, and partly from the denſity of the glaſs in the pots being greater the lower its poſition.

Various have been the attempts to remedy theſe defects, more eſpecially ſince the Board of Longitude has offered a conſiderable premium for this object. We do not, however, poſſeſs any ample detail of theſe unſucceſsful experiments. It is generally underſtood, that it is in vain to endeavour to make this glaſs in ſmall furnaces, becauſe the heat in theſe is continually varying, and is either too low for the requiſite fluidity, or ſo high as to extricate bubbles of elaſtic matter; whereas a ſteady heat is required for the purpoſe. Macquer and others have attempted to correct the evil by repeated fuſions and pulverization of the glaſs, and by expoſing it to long continued fires; but without ſucceſs. It is ſaid, that one of the practices in our glaſs-houſes conſiſts in lading the melted matter from one pot to another in the furnace. But this, on account of the heavy duty of exciſe, and the impolitic manner in which it is levied, cannot be done to any great extent in this country. If the glaſs be ſuffered to cool in the pots after a good fuſion, its parts take a ſymmetrical arrangement, of the nature of cryſtallization, by which the light is acted upon in a manner independent of its figure, which is thought to be a great impediment to its optical uſe. Mr. Kier, who has had much experience in this branch of chemiſtry, is diſpoſed to recommend the trial of component parts different from any which have yet been admitted into the common glaſſes.

Without preſuming to ſpeculate in a department of ſcience wherein my experience is much confined, I ſhall point out a few facts which may be of uſe to the philoſophical operator, and leave the manufacturer to his own trials. It is generally affirmed, that Mr. Dollond made his original experiments, and conſtructed thoſe excellent three-foot glaſſes (which at preſent bear ſo high a price, and are not to be made) with one ſingle pot of glaſs made at the glaſs-houſe near Wellcloſe Square, and that none of the ſame quality has ſince been made. But the proprietor of that glaſs-houſe has aſſured me, that the original receipts and practice are ſtill followed

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in the making of optical glaſs: that the principal opticians always complain of the bad quality of the glaſs, but never fail to take the whole quantity he makes at their requeſt; and that when they renew their orders, they always deſire it may be exactly the ſame as the laſt. From theſe circumſtances I think it probable, 1. That though one pot of glaſs may differ from another, yet there may be as good glaſs obtained for optical uſes now as formerly, if an optician ſkilled in the theory and practice, like the late Mr. Dollond, were to undertake the taſk of adapting the curvatures, and ſelecting the beſt lenſes. 2. That Mr. Dollond's purpoſe as a tradeſman being now anſwered, by the eſtabliſhment of an extenſive buſineſs, he has not the ſame motives for exertion upon powerful teleſcopes as actuated his father. 3. That the profits of this trade are greater, and more certain, when many hundreds of cheap perſpectives are made by common workmen, than when a few extraordinary teleſcopes are made by the moſt excellent artiſts, ſuperintended by the maſter himſelf; and, conſequently, it is not the intereſt of an eſtabliſhed houſe to extend the latter branch. 4. That it is not the intereſt of a glaſs manufacturer, who can gain a large and regular income by making common utenſils, to employ his time in coſtly experiments upon optical glaſs, which, if brought to perfection, would afford but a moderate demand, probably no greater than he now experiences: and, therefore, that the improvement of achromatic teleſcopes is rather to be expected from a man of ſcience, who may be a practical chemiſt, than from mere tradeſmen.

I ſuſpect the opinion to be ill founded, that thoſe kinds of glaſſes are unfit for optical uſes, which are veiny or clouded, or otherwiſe unpromiſing. On the contrary, there are reaſons to think that the defects of glaſs ariſe from irregularities too minute and numerous to be diſcerned or diſcovered in any way, but by the actual proof of conſtructing a teleſcope. There are good glaſſes which abound with the larger veins; and I poſſeſs two achromatic lenſes, each of thirty inches focus, whoſe obvious qualities, and excellence as object glaſſes, differ very much, and in oppoſite reſpects. They are each compoſed of a convex of crown-glaſs applied to a concave of flint. The one was conſtructed for the tube of an aſtronomical quadrant. It produces no colour, has no aberration from figure, and, when the eye is placed in its focus ſo as to receive the pencil of light from a fixed ſtar, the whole aperture is uniformly covered with light. The other glaſs, though perfectly ſimilar, was made for a pocket perſpective. It produces ſcarcely any colour, has conſiderable aberration from figure, and, when the eye placed in its focus receives the light of a fixed ſtar, the whole aperture is covered with light of an irregular, curdled, or clouded appearance. I have no doubt but the former glaſs was applied to the ſuperior, and the latter to the inferior uſe, from their obvious qualities: but when they are examined by the true teſt of optical excellence, the application of a large magnifying power, the former proves dark and indiſtinct, while the latter exhibits the object bright and well defined, and is on the whole an excellent lens.

Mr. Reaumur was the firſt who made any direct experiments upon the converſion of glaſs into porcelain, which takes place by the evaporation or abſorption of its alkali, during the continuance of a degree of heat leſs than is ſufficient to melt it. Saline glaſſes are the beſt for this purpoſe; and the leſs ſalt they contain, the more readily they are converted. Inſtances of this effect may be obſerved among the rubbiſh of brick-kilns, where pieces of green bottles are not unfrequently ſubjected by accident to the requiſite heat; but the direct proceſs is as follows:

A veſſel of green glaſs is to be filled up to the top with a mixture of white ſand and gypſum, and then ſet in a large crucible upon a quantity of the ſame mixture, with which the glaſs veſſels muſt alſo be ſurrounded and covered over, and the whole preſſed down rather hard. The crucible is then to be covered with a lid, the junctures well luted, and put into a potter's kiln, where it muſt remain during the whole time that the pottery is baking; after which, the glaſs veſſel will be found transformed into a milk-white porcelain. The glaſs, on fracture, appears fibrous, as if it were compoſed merely of ſilken threads laid by the ſide of each other: it has alſo quite loſt the ſmooth and ſhining appearance of glaſs, is very hard, and emits ſparks of fire when ſtruck with ſteel, though not ſo briſkly as real porcelain. Lewis obſerved, that the above-mentioned materials have not excluſively this effect upon glaſs; but that powdered charcoal, ſoot, tobacco-pipe clay, and bone-aſhes, produce the ſame change. It is remarkable, that the ſurrounding ſand becomes in ſome meaſure agglutinated by this proceſs, which, if continued for a ſufficient length of time, entirely deſtroys the texture of the glaſs, and renders it pulverulent.

For the other properties and circumſtances relative to glaſs, ſee ENAMEL, POTTERY, and the ſeveral metallic ſubſtances.

GLAUBER's SALT. The combination of vitriolic acid and mineral alkali.

It contains 15 parts alkali, 27 acid, and 58 water, according to Bergman. *See* ACID VITRIOLIC.

GLIMMER. A name occaſionally applied to micaceous earths.

GLUTEN, VEGETABLE. If wheat flower be made into a paſte, and waſhed in a large quantity of water, it is ſeparated into three diſtinct ſubſtances; a mucilaginous ſaccharine matter, which is readily diſſolved in the liquor, and may be ſeparated from it by evaporation; ſtarch, which is ſuſpended in the fluid, and ſubſides to the bottom by repoſe; and gluten, which remains in the hand, and is tenacious, very ductile, ſomewhat elaſtic, and of a brown grey colour. The firſt of theſe ſubſtances does not eſſentially differ from other ſaccharine mucilages. The ſecond, namely the ſtarch, forms a gluey fluid by boiling in water, though it is ſcarcely, if at all, acted upon by that fluid when cold. Its habitudes and products with the fire, or with nitrous acid, are nearly the ſame as thoſe of gum and of ſugar. It appears to be as much more remote from the ſaline ſtate than gum, as gum is more remote from that ſtate than ſugar.

The vegetable gluten, though it exiſted, before the waſhing, in the pulverulent form, and has acquired its tenacity and adheſive qualities from the water it has imbibed, is nevertheleſs totally inſoluble in that fluid. It has ſcarcely any taſte. When dry, it is ſemi-tranſparent, and reſembles glue in its colour and appearance. If it be drawn out thin, when firſt obtained, it may be dried by expoſure to the air; but if it be expoſed to warmth and moiſture while wet, it putrifies like an animal ſubſtance. The dried gluten applied to the flame of a candle, crackles, ſwells, and burns, exactly like a feather or piece of horn. It affords the ſame products by deſtructive diſtillation as animal matters do: is not ſoluble in ardent ſpirit, oils, or ether; and is acted upon by acids and alkalis, when heated. *See* BREAD.

GLUE. An inſpiſſated jelly made from the parings of hides and other offals, by boiling them in water, ſtraining through a wicker baſket, ſuffering the impurities to ſubſide, and then boiling it a ſecond time. In this ſtate it is poured into flat frames or moulds; then cut into ſquare pieces when congealed, and afterwards dried in a coarſe net. It is ſaid to improve by age; and that glue is reckoned

reckoned the beſt which ſwells conſiderably without melting by three or four days infuſion in cold water, and recovers its former dimenſions and properties by drying. *See* JELLY.

GNEIS. The Saxon name of a rock, conſiſting of mica, lapis ollaris, and quartz.

GOLD is a yellow metal, of much greater ſpecific gravity than any other body in nature, except platina. It is ſoft, very tough, ductile, and malleable; unalterable and fixed, whether expoſed to the atmoſphere, or to the ſtrongeſt heat of furnaces. The moſt powerful burning mirrors are ſaid to have volatilized it; and it has been driven up in fumes, in the metallic ſtate, by flame urged upon it by a ſteam of dephlogiſticated air. The electric ſhock converts it into a purple calx, as may be ſeen by tranſmitting that commotion through gold leaf between two plates of glaſs; or by cauſing the exploſive ſpark of three or more ſquare feet of coated glaſs to fall upon a gilded ſurface. A ſtrong heat is required to melt it, which does not happen till after ignition. Its colour, when melted, is of a bluiſh green; and the ſame colour is exhibited by light tranſmitted through gold leaf.

The limits of the ductility and malleability of gold are not known, and its tenacity exceeds that of any other metal. A gold wire, of one tenth of an inch diameter, requires 500lb. weight to break it.

The method of extending gold uſed by the gold-beaters, conſiſts in hammering a number of thin-rolled plates between ſkins or animal membranes. By the weight and meaſure of the beſt wrought gold-leaf, it is found that one grain is made to cover $56\frac{3}{4}$ ſquare inches; and from the ſpecific gravity of the metal, together with this admeaſurement, it follows, that the leaf itſelf is $\frac{1}{282000}$ part of an inch thick. This, however, is not the limit of the malleability of gold; for the gold-beaters find it neceſſary to add three grains of copper in the ounce to harden the gold, which otherwiſe would paſs round the irregularities of the neweſt ſkins, and not over them; and in uſing the old ſkins, which are not ſo perfect and ſmooth, they proceed ſo far as to add twelve grains. The wire which is uſed by the lace-makers is drawn from an ingot of ſilver, previouſly gilded. In this way, from the known diameter of the wire, or breadth when flattened, and its length, together with the quantity of gold uſed, it is found, by computation, that the covering of gold is only $\frac{1}{172}$ part of the thickneſs of gold-leaf, though it ſtill is ſo perfect as to exhibit no cracks when viewed by a microſcope.

No acid acts readily upon gold but aqua regia and the dephlogiſticated marine acid. The vitriolic acid, diſtilled from manganeſe, has ſome action upon it; as have likewiſe the pale nitrous acid, and the phoſphoric acid when boiling.

The ſmall degree of concentration which the dephlogiſticated marine acid is ſuſceptible of, and the imperfect action of the latter acids, render aqua regia the moſt convenient ſolvent for this metal.

When gold is immerſed in aqua regia, an effervescence takes place with the eſcape of air, which has not been examined; the ſolution tinges animal matters of a deep purple, and corrodes them. By careful evaporation, fine cryſtals of a topaz colour are obtained. The gold is precipitated from its ſolvent by a great number of ſubſtances. Lime and magneſia precipitate it in the form of a yellowiſh powder. Alkalis exhibit the ſame appearance; but an exceſs of alkali redilſolves the precipitate. The precipitate of gold obtained from aqua regia by the addition of a fixed alkali, appears to be a true calx, and is ſoluble in the vitriolic, nitrous,

and marine acids; from which, however, it ſeparates by ſtanding, or by evaporation of the acids. The nut-gall precipitates gold of a reddiſh colour, very ſoluble on the nitrous acid, to which it communicates a fine blue colour.

The volatile alkali precipitates the ſolution of gold much more readily than fixed alkalis. This precipitate, which is of a brown, yellow, or orange colour, poſſeſſes the property of detonating with a very conſiderable noiſe, when gently heated. It is known by the name of fulminating gold. The preſence of volatile alkali is neceſſary to give the fulminating property to the precipitate of gold; and it will be produced by precipitating it with fixed alkali from an aqua regia previouſly made by adding ſal ammoniac to nitrous acid; or by precipitating the gold from pure aqua regia, by means of ſal ammoniac, inſtead of the volatile alkali alone. The fulminating gold weighs one-fourth more than the gold made uſe of. A conſiderable degree of precaution is neceſſary in preparing this ſubſtance. It ought not to be dried but in the open air, at a diſtance from a fire, becauſe a very gentle heat may cauſe it to explode. Several fatal accidents have ariſen from its exploſion, in conſequence of the friction of ground ſtoppers in bottles containing this ſubſtance, of which a ſmall portion remained in the neck.

Fulminating gold, when expoſed by Berthollet to a very gentle heat in a copper tube, with the pneumatical apparatus of mercury, was deprived of its fulminating quality, and converted into a calx at the ſame time that alkaline air was diſengaged. From this dangerous experiment it is aſcertained, that fulminating gold conſiſts of calx of gold combined with the volatile alkali. The ſame eminent philoſopher cauſed fulminating gold to explode in copper veſſels. Phlogiſticated air was diſengaged, a few drops of water appeared, and the gold was reduced to the metallic form. In this experiment he infers, that the volatile alkali was decompoſed; that the phlogiſticated air, ſuddenly aſſuming the elaſtic ſtate, cauſed the exploſion, while the vital air of the calx united with the inflammable air of the alkali, and formed the water.

This ſatisfactory theory was ſtill further confirmed by the decompoſition of fulminating gold, which takes place in conſequence of the action of the concentrated vitriolic acid, of melted ſulphur, fat oils, and ether; all which deprived it of its fulminating quality, by combining with its volatile alkali.

Liver of ſulphur precipitates gold from its ſolvent; the alkali uniting with the acid, and the gold falling down combined with the ſulphur; of which, however, it may be deprived by moderate heat.

Moſt metallic ſubſtances precipitate gold from aqua regia: lead, iron, and ſilver, precipitate it of a deep and dull purple colour; copper and iron throw it down in its metallic ſtate; biſmuth, zinc, and mercury, likewiſe precipitate it. A plate of tin, immerſed in a ſolution of gold, affords a purple powder, called the purple powder of Caſſius, which is uſed to paint in enamel. There are various methods of managing this proceſs. That deſcribed by Macquer conſiſts in diſſolving tin by very ſmall portions at a time, without heat, in an aqua regia compoſed of two parts of nitrous and one of marine acid, previouſly weakened with water equal in weight to both the acids. The firſt ſmall portion of tin muſt be ſuffered to be entirely diſſolved before a ſecond is added. This addition muſt be continued till the acid has acquired a yellow colour, and ſcarcely acts at all upon the tin laſt added.

On the other hand, the pureſt gold muſt be diſſolved in an aqua regia compoſed

poſed of three parts of nitrous, and one of marine acid. This ſolution may be made, as expeditiouſly as the operator chooſes, by the aſſiſtance of the heat of a ſand bath.

The ſolution of tin muſt then be largely diluted, as for example, with one hundred parts of diſtilled water; and a ſmall quantity of this may then be aſſayed, by ſeparating it into two parts, and diluting one of the parts ſtill farther. Upon trial of both, by letting fall a drop of the ſolution of gold into each, it will be ſeen which affords the moſt beautiful purple precipitate. The whole of the ſolution of tin muſt accordingly be altered, if neceſſary, by adding more water. Pour into this ſolution, in a large glaſs or earthen veſſel, nearly half as much of the ſolution of gold as it contains of ſolution of tin, ſtirring the mixture with a glaſs ſtick. In a ſhort time the liquor will become of a beautiful red colour, which will gradually diſappear on the ſubſidence of the precipitate. By adding a ſmall quantity of the ſolution of tin, it will be ſeen whether the whole of the gold is precipitated. The clear liquor muſt then be decanted, and the precipitate waſhed. It conſiſts of the calces of gold and tin in combination, and is the only known ſubſtance which has the property of communicating a purple colour to glaſs.

The difficulties attending the preparation of this article appear to depend on the ſtate of the tin. If the ſolution of this metal be made with heat and rapidity, it becomes too much calcined to adhere to the acid, or to precipitate the gold; and the combination of the two metals, which falls down, varies in colour according as this term is approached. Theſe are the chief circumſtances; but there is no doubt but that a complete examination of the proceſs would indicate others worthy of notice.

Ether, naphtha, and eſſential oils, take gold from its ſolvent, and form liquors which have been called potable gold. The gold which is precipitated by evaporation of theſe fluids, or by the addition of martial vitriol to the ſolution of gold, is of the utmoſt purity.

In the dry way, gold reſiſts the action of neutral ſalts, more eſpecially nitre, which deflagrates with the imperfect metals. Nitre, however, does not afford an expeditious way of purifying gold, becauſe this metal in ſome meaſure protects and covers the alloys from its action. It is remarked, that borax, uſed as a flux with gold, renders it paler; and that this alteration of colour diſappears by the addition of nitre or common ſalt. As the acid of borax forms a compound with gold, which falls to the bottom when this acid is added to the metal in ſolution, it is probable that the paleneſs produced by borax may ariſe from the combination of a ſmall portion of its acid with the gold, which might be driven off by a continuance of the heat, and united by ſtronger affinity with the alkali of the nitre, or of the common ſalt, in proportion as their acids are diſſipated by heat.

Earths and alkalis do not act on gold in the dry way. Sulphur, which combines with moſt metals, has no effect on this. A proceſs, called dry parting, is grounded on this property; and is more eſpecially uſed in ſeparating ſilver from gold, when the quantity of this latter metal is too ſmall to anſwer the charges of diſſolving the larger maſs of ſilver in nitrous acid. For this purpoſe, the mixed metal is fuſed, and flowers of ſulphur thrown on its ſurface. This combines with the ſilver in the form of a black ſcoria, while the gold remains at the bottom in its metallic ſtate. The operation of dry parting does not leave the gold in a ſtate

of purity; becauſe the laſt portions of ſilver are defended from the action of the ſulphur. But when the quantity of ſilver is thus diminiſhed, the operation of parting, with aqua fortis, or nitrous acid, may be advantageouſly uſed.

Liver of ſulphur diſſolves gold in the dry way. Equal parts of ſulphur and vegetable alkali are haſtily fuſed with one fourth of a part of gold-leaf. This combination is ſoluble in water, with which it forms a yelloviſh green ſolution. By the addition of an acid, the gold is thrown down in combination with the ſulphur, of which it may be deprived by heat.

Moſt metals unite with gold by fuſion. With ſilver it forms a compound, which is paler in proportion to the quantity of ſilver added. It is remarkable that a certain proportion, for example a fifth part, renders it greeniſh. From this circumſtance, as well as from that of a conſiderable proportion of theſe metals ſeparating from each other by fuſion, in conſequence of their different ſpecific gravities, when their proportions do not greatly differ, it ſhould ſeem that their union is little more than a mere mixture without combination: for, as gold-leaf tranſmits the green rays of light, it will eaſily follow, that particles of ſilver, enveloped in particles of gold, will reflect a green, inſtead of a white light.

A ſtrong heat is neceſſary to combine platina with gold: it greatly alters the colour of the gold, if its weight exceed the forty-ſeventh part of the maſs. It does not much affect the ductility. The Spaniſh miniſtry has prohibited the exportation of platina from America, leſt it ſhould be uſed in adulterating gold; but this does not appear to be a danger which need be feared, as chemiſtry has long been in poſſeſſion of ſeveral ſimple and expeditious methods of detecting this fraud, which beſides is evident to the ſight when the quantity of debaſement is conſiderable. It may be queſtioned likewiſe, whether the value of platina would not ſoon equal that of gold, if its properties and uſes were better known in ſociety.

Mercury is ſtrongly diſpoſed to unite with gold, in all proportions with which it forms an amalgam: this, like other amalgams, is ſofter the larger the proportion of mercury. It ſoftens and liquifies by heat, and cryſtallizes by cooling.

Lead unites with gold, and conſiderably impairs its ductility. Copper renders gold leſs ductile, harder, more fuſible, and of a deeper colour. This is the uſual addition in coin, and other articles uſed in ſociety. Tin renders it brittle in proportion to its quantity; but it is a common error of chemical writers to ſay, that the ſlighteſt addition is ſufficient for this purpoſe. With iron it forms a grey mixture, which obeys the magnet. This metal is very hard, and is ſaid to be much ſuperior to ſteel for the fabrication of cutting inſtruments. Biſmuth renders gold white and brittle; as do likewiſe nickel, arſenick, and antimony. Zinc produces the ſame effect; and, when equal in weight to the gold, a metal of a fine grain is produced, which is ſaid to be well adapted to form the mirrors of reflecting teleſcopes, on account of the fine poliſh it is ſuſceptible of, and its not being ſubject to tarniſh. The alloys of gold with the regulus of manganeſe, or molybdena, are not known. It could not be mixed with regulus of wolfram, on account of the infuſibility of this laſt ſubſtance.

Gold is found moſtly in the metallic ſtate, though generally alloyed with ſilver, copper, iron, or all three. It is found either in ſeparate lumps, or viſible grains, among the ſands of rivers in many parts of Europe and elſewhere. The quantity is for the moſt part inſufficient to pay the coſt of ſeparating it; but it is thought to be more univerſally diffuſed in ſands and earths than any other metal, except iron.

iron. The greateſt quantity of gold is imported into Europe from South America. Some is brought from the Eaſt Indian iſlands and China, and ſome from the coaſt of Africa. The principal gold mines in Europe are thoſe of Hungary. Some ſands afford gold by ſimple waſhing; the heavy metallic particles ſubſiding ſooneſt: but when it is bedded in earths or ſtones, theſe ſubſtances are pounded, and boiled with one-tenth of their weight of mercury together with water. The mercury, after a certain time, abſorbs the gold, and may be ſeparated by preſſure through leathern bags, and ſubſequent diſtillation. Or otherwiſe, if the ſand be heated red hot, and quenched in water ſeveral times, for the purpoſe of cracking and dividing it, and the whole be then melted into glaſs, with twice its weight of the calx of lead called litharge, and charcoal powder be then added, the lead will be revived in the metallic ſtate, and will carry the gold along with it. By expoſure to a proper degree of heat, with acceſs of air, the lead may again be converted into litharge, and the gold will be left pure. This laſt operation is, in fact, a method of aſſaying ſands which contain gold, rather than of obtaining it from them in the large way.

Gold is alſo found in certain martial pyrites in Sweden and elſewhere; from which it may be extracted by torrefaction or burning of the ſulphur, and ſubſequent digeſtion in aqua regia.

To obtain gold in a ſtate of purity, or to aſcertain the quantity of alloy it may contain, it is expoſed to a ſtrong heat, together with lead, in a porous crucible. This operation is called cupellation, and is performed as follows:—The precious metal is put, together with a due proportion of lead, into a ſhallow crucible made of burned bones, called a cupel; and the fuſion of the metals is effected by expoſing them to a conſiderable heat in a muffel, or ſmall earthen oven, fixed in the midſt of a furnace. The lead continually vitrifies, or becomes converted into a glaſſy calx, which diſſolves all the imperfect metals. This fluid glaſs, with its contents, ſoaks into the cupel, and leaves the precious metal in a ſtate of purity. During the cupellation, the ſcoriæ, running down on all ſides of the metallic maſs, produce an appearance called circulation, by which the operator judges whether the proceſs is going on well. When this metal is nearly pure, certain priſmatic colours flaſh ſuddenly acroſs the ſurface of the globulæ, which ſoon afterwards appears very brilliant and clean: this is called the brightening, and ſhews that the ſeparation is ended.

After gold has paſſed the cupel, it may ſtill contain either of the other perfect metals, platina or ſilver. The former is ſeldom ſuſpected; the latter is ſeparated by the operations called quartation and parting. Quartation conſiſts in adding three parts of ſilver to the ſuppoſed gold, and fuſing them together, by which means the gold becomes one-fourth of the maſs only. The intention of this is to ſeparate the particles of gold from each other, ſo that they may not cover and defend the ſilver from the action of the pure nitrous acid which is to be uſed in the proceſs of parting. Parting conſiſts in expoſing the maſs, previouſly hammered or rolled out thin, to the action of boiling aqua fortis of a due ſtrength. If the acid be not too concentrated, it diſſolves the ſilver, and leaves the gold in a porous maſs of the original form; but if too ſtrong, the gold is in a powdery form, which may be waſhed and dried. The weight of the original metal before cupellation, and after the ſubſequent operations, ſerve to aſcertain the degree of fineneſs of the ingot, or ore, of which it was a part.

The quantity of alloy is never conſidered as part of the value of metals which

contain either gold or ſilver. In eſtimating or expreſſing the fineneſs of gold, the whole maſs ſpoken of is ſuppoſed to weigh twenty-four carats of twelve grains each, either real or merely proportional, like the aſſayers weights; and the pure gold is called fine. Thus, if gold be ſaid to be twenty-three carats fine, it is to be underſtood that, in a maſs weighing twenty-four carats, the quantity of pure gold amounts to twenty-three carats.

In ſuch ſmall works as cannot be aſſayed by ſcraping off a part, and cupelling it, the aſſayers endeavour to aſcertain its quality or fineneſs by the touch. This is a method of comparing the colour and other properties of a minute portion of the metal, with thoſe of certain ſmall bars whoſe compoſition is known. Theſe bars are called touch-needles; and they are rubbed upon the black baſaltes, which, for that reaſon, is called the touchſtone. Black flint, or pottery, will ſerve the ſame purpoſe. Sets of golden needles may conſiſt of pure gold; pure gold $23\frac{1}{2}$ carats with half a carat ſilver; 23 carats gold with one carat ſilver; $22\frac{1}{2}$ carats gold with $1\frac{1}{2}$ carat ſilver, and ſo forth, till the ſilver amounts to four carats, after which, the additions may proceed by whole carats. Other needles may be made in the ſame manner, with copper inſtead of ſilver; and other ſets may have the addition, conſiſting either of equal parts ſilver and copper, or ſuch proportions as the occaſions of buſineſs require.

In foreign countries, where trinkets and ſmall work are required to be ſubmitted to the aſſay of the touch, a variety of needles are neceſſary; but they are not much uſed in England. They afford, however, a degree of information, which is more conſiderable than might at firſt be expected. The attentive aſſayer not only compares the colour of the ſtroke made upon the touchſtone by the metal under examination, with that produced by his needle, but will likewiſe attend to the ſenſation of roughneſs, dryneſs, ſmoothneſs, or greaſineſs, which the texture of the rubbed metal excites, when abraded by the ſtone. When two ſtrokes, perfectly alike in colour, are made upon the ſtone, he may then wet them with aqua fortis, which will affect them very differently, if they be not ſimilar compoſitions; or the ſtone itſelf may be made red hot by the fire, or by the blow-pipe, if thin black pottery be uſed, in which caſe the phenomena of calcination will differ according to the nature and quantity of the alloy.

Gold ores may be aſſayed in the moiſt way by pounding them very fine, weighing a determinate portion, and attempting their ſolution in nitrous acid, which will diſſolve the matrix if it conſiſt of calcareous earth; or if it be ſelenite, the powder may be digeſted in aqua regia as long as any metallic ſubſtance is taken up; after which the gold may be precipitated by an addition of vitriol of iron, which will cauſe it to fall down in the metallic ſtate.

The principal uſe of gold is, as the medium of exchange in coin, for which it has been choſen to occupy the firſt place, on account of its ſcarcity, its great weight, and its not being ſubject to tarniſh. The gold coins of Great Britain contain eleven parts of gold, and one of copper.

Gold is likewiſe uſed in gilding; for which purpoſe, as we have already ſhewn, it is mechanically divided into leaves of extreme thinneſs. Theſe are ſtuck upon wood, previouſly ſmeared with adheſive oil, or animal glue called ſize. The proceſs called water-gilding, which is uſually applied to copper or braſs, is performed by immerſing the clean copper into a diluted ſolution of mercury. The copper is corroded by the acid, which at the ſame time depoſits a thin coating of mercury. This coating, after the piece is waſhed, facilitates the adheſion of an amalgam of gold, which is then to be rubbed upon it. The mercury is afterwards volatilized

by heat; and the work is finiſhed by burning gilding wax upon it, which is a compoſition of red bole, verdigreaſe, alum, and bees-wax. The intention of this laſt application appears to be that of concealing the defects of the gilding.

There is another method of gilding, which is performed by ſteeping linen rags in a ſolution of gold. Theſe are afterwards dried and burned to aſhes, which contain gold in a very divided ſtate. Nothing more is neceſſary than to moiſten the end of a cork, and dip it in this burned matter, together with a little wood aſhes, and rub it upon the face of the ſilver intended to be gilded. By this means the gold eaſily adheres.

The other uſes of gold, in laces, &c. are ſufficiently known.

GRANITE, a compound rock, conſiſting of quartz, feltſpar, and mica, and occaſionally hornblende, ſteatites, garnet, or baſaltes. It is ſeen among the paving ſtones of London, conſiſting of quartz of a white colour, a reddiſh feltſpar, and black or violet ſhoerl. The parts of granite are ſo well adapted to each other, that Mr. de Sauſſure concludes it to have been the product of confuſed cryſtalliſation.

The granite is called moorſtone in Engliſh. The proportion and ſize of its component parts are extremely variable, as well as their colour. The quartz, feltſpar, and mica, conſtitute the hardeſt ſort of granite, the moſt anciently known. That into which the ſhoerl enters is more ſubject to decompoſition. The granite never has any particular texture or regular form, but conſiſts of enormous ſhapeleſs maſſes, of great hardneſs.

In the finer granites, the quartz is tranſparent; in others, generally white or grey, violet or brown. The feltſpar, white, yellow, red, green, or black, is generally the moſt copious ingredient. The mica is alſo grey, brown, yellow, green, red, violet, or black, and is commonly leaſt copious. The ſhoerl is generally black, and abounds in the granites that contain it.

Hence the colour of granites chiefly depends on that of the ſpar or ſhoerl. The red granites conſiſt commonly of white quartz, red feltſpar, and grey mica. The grey of white quartz, grey or violet feltſpar, and black mica. The black commonly contain ſhoerl inſtead of feltſpar; and the green commonly contain green quartz.

If granite be expoſed to the flame, urged by a blow-pipe, its different concretions ſeparate from each other. In a crucible, Mr. Gerhard found the feltſpar of a piece of granite melted into a tranſparent glaſs; under it the mica lay in the form of a black ſlag, and the quartz remained unaltered. But when all three were powdered and mixed, it melted ſomewhat better; yet ſtill the quartz may be diſtinguiſhed by the help of a lens. This well explains why ſmall white grains are frequently found in lavas. The experiments of Meſſrs. d'Arcet and Sauſſure perfectly coincide on this ſubject.

The mixture of mica prevents the ſilex or quartz from cracking or ſplitting; and hence its infuſibility and advantageous uſe in furnaces.

The granitone, mentioned by Ferber, in his Letters from Italy, is a ſtone compoſed of feltſpar and mica. A ſubſtance of this kind, which moulders by being long expoſed to the air, is found in Finland: it is ſaid to contain ſometimes ſaltpetre, and ſometimes common ſalt. It is there called raparkivi. Wallerius deſcribes eighteen ſpecies of granites, beſides many other granatic ſtones, on which the curious reader may conſult his Mineralogic Syſtem of the edition in 1778.

GRANULATION. The method of dividing metallic ſubſtances into grains

or ſmall particles, in order to facilitate their combination with other ſubſtances, and ſometimes for the purpoſe of readily ſubdividing them by weight.

As the entire metals cannot be pulveriſed, becauſe not ſufficiently brittle, and as the mechanical ſubdiviſion of their parts is attended with conſiderable labour and difficulty, recourſe is generally had to fuſion; and the ſubdiviſion is made at the inſtant of congelation. This is done either by pouring the melted metal into water, or by agitating it in a box until the moment of congelation, at which inſtant the whole becomes converted into a powder. Theſe different proceſſes are preferable the one to the other, according to the nature of the metallic ſubſtance. Thus gold, ſilver, copper, or iron, cannot be granulated by agitation, not only becauſe the great heat required for their fuſion would be productive of inconvenience, but likewiſe becauſe they poſſeſs a great degree of tenacity when heated almoſt to melting. Lead, tin, and braſs, on the contrary, are very brittle when heated, and are therefore beſt granulated in this way.

Various contrivances are uſed to prevent danger and inſure ſucceſs in the ſeveral manufactories that require granulation. Copper is granulated for making braſs, by pouring it through a perforated ladle into a covered veſſel of water with a moveable falſe bottom. A compound metal, conſiſting chiefly of lead, is poured into water through a perforated veſſel of another kind, for making ſmall ſhot, in which the height above the ſurface of the fluid is ſaid to require particular adjuſtment. But in a new manufactory of this kind, we underſtand that the height is very great, being upwards of one hundred feet.

GRAVITY, a term uſed by phyſical writers to denote the cauſe by which all bodies move towards each other, unleſs prevented by ſome other force or obſtacle. Its effects on the motions of the celeſtial bodies are explained by aſtronomical writers. The moſt familiar effect, and that which continually obtrudes itſelf on our notice, is the weight of bodies, or their tendency towards the centre of the earth. Though the phenomena ariſing from the weight of bodies form the baſis of a ſeparate ſcience called mechanics, yet they are of great conſequence to the chemiſt. It has not been aſcertained, or rendered probable, that gravity is a ſecondary property of matter; that is to ſay, that it flows from any of the other known original properties. Sir Iſaac Newton, however, was of opinion, that our reaſonings on the ſubject might be ſimplified, by ſuppoſing it to depend on a prodigiouſly elaſtic and rare fluid, by him called ether, and aſſumed to poſſeſs an increaſing degree of condenſation, in parts of ſpace more and more remote from the various maſſes of matter. According to this doctrine, a falling body moves, becauſe it is preſſed towards the rarer parts of this extended fluid. We ſhall leave this theory to its merits, as being neither very perſpicuous, nor much related to our ſubject. Bergman and others have conſidered the chemical and coheſive attractions to be one and the ſame with the attraction of gravity; but modified in its laws, by variations in the maſſes, denſities, and diſtances of the particles of bodies. Many difficulties appear at firſt ſight to offer themſelves againſt this ſuppoſition. But in truth it cannot be examined at firſt ſight; but requires to be ſubmitted to the rigour of mathematical inveſtigation. I do not know that any attempt of this nature has been made. *See* ATTRACTION.

GRAVITY, SPECIFIC. Boyle is among the firſt of our philoſophers who ſuggeſted the advantage that chemiſtry and mineralogy might derive from an attention

attention to the ſpecific gravities of bodies. Much advantage may indeed be derived from this property in the general determination of the claſſes of minerals, and the purity of ſome metallic bodies; and it is very probable, that an attention to the ſpecific gravities, capacities for heat, fuſibilities, volatilities, laws of cryſtaliſation, elaſticity, hardneſs, tenacity, malleability, and ſome other obvious ſpecific properties of bodies, may produce a more intimate acquaintance with the mutual actions of their particles, than any we have hitherto acquired.

Annexed to this article is a table of ſpecific gravities. In compiling this, I had Briſſon's table at the end of Lavoiſier's Traité Elementaire de Chemie, and Muſchenbroek's large table in his Cours de Phyſique, before me. Some few ſpecific gravities are from other authors, or from experiment. It appeared uſeleſs to carry it to more than four places of figures, as the temperatures were not noted; and the various ſpecimens of the ſame ſubſtance often differ in the third figure. Theſe aſſertions may be thought to require proof: for which reaſon I ſhall obſerve that, by experiment, I find that the fifth figure changes in water at every three degrees of Farenheit's thermometer; that lead, tin, and probably all other metals, though caſt out of the ſame fuſion, will vary in their ſpecific gravities in the third figure, from circumſtances not yet determined, but moſt likely from the cooling, as is ſeen in the hardening of ſteel; that ſalts, and other artificial preparations, retain more or leſs of the ſolvent they were ſeparated from, according to the temperature at which the cryſtallization was effected; and that all parts of organized ſubſtances not only differ according to the place of their production, their age, and other circumſtances, but likewiſe from their dryneſs, moiſture, and manner of preſervation.

The ſpecific gravity of ſolids is determined by weighing them firſt in air, and then in water. The loſs of weight ariſing from the action of the water, is equal to that of a maſs of the fluid poſſeſſing the ſame dimenſions as the ſolid itſelf. Whence it is eaſy to conſtruct a general table of ſpecific gravities, by reducing the proportion of the abſolute weight to the loſs ſuſtained by immerſion, into terms of which that expreſſing water ſhall be unity. If the ſolid be ſo light as to float upon water, it is convenient to attach to it another heavier body ſufficient to cauſe it to ſink, but whoſe weight in water muſt be added in computing the loſs. The ſpecific gravity of fluids is aſcertained by weighing a known body immerſed in them. For the loſs by immerſion will accurately ſhew the weight of the ſame bulk of the fluid; and, conſequently, the proportion of theſe ſeveral quantities to the loſs the ſame ſolid ſuſtained in water, being reduced as in the other caſe to the common ſtandard of unity, will exhibit the ſpecific gravity. Other methods are likewiſe uſed in experiments with fluids. Thus equal bulks of different fluids may be weighed by filling a ſmall bottle with a ground ſtopper with each reſpectively, and from their ſeveral weights the weight of the bottle and ſtopper muſt be deducted. Or otherwiſe, the inſtrument called the hydrometer may be uſed. *See* HYDROMETER. This poſſeſſes the advantage of portability, ſpeed, and a degree of accuracy not eaſily obtained by the uſe of ordinary balances.

A TABLE

A TABLE

Shewing the Specific Gravity of Metals and other Bodies to Rain Water, and the Weight of a Cubic Inch of each, in Parts of a Pound Averdupoiſe.

Bodies.	Sp. Gravity.	W. lb. Averd.	Bodies.	Sp. Gravity.	W. lb. Averd.
Pure gold caſt	19258	0,71036	Muſcovy talc	2792	0,10098
——— hammered	19362	0,70030	Common ſlate	2672	0,09664
Standard gold caſt	17486	0,63250	Calcareous ſpar	2715	0,09820
——— hammered	17589	0,63618	Alabaſter	2730	0,09874
Pure ſilver caſt	10474	0,37796	White marble	2716	0,09823
——— hammered	10511	0,38017	Limeſtones, from	1386	0,05113
Standard ſilver in coin	10391	0,37580	——— to	2390	0,08644
Crude platina in grains	15602	0,56431	Ponderous ſpar	4474	0,16182
Platina purified and fuſed	19500	0,70530	Fluor ſpar	3180	0,11502
——— hammered	20377	0,73557	Pumice-ſtone	914	0,03306
——— drawn into wire	21042	0,76107	Green glaſs	2620	0,09476
——— laminated	22069	0,79821	Engliſh crown-glaſs	2520	0,09115
Mercury	13568	0,49074	White flint-glaſs, Engliſh	3290	0,11900
Lead fuſed	11352	0,40965	Another piece	3216	0,11632
Copper fuſed	7788	0,28168	White flint glaſs for achromatic uſes	3437	0,12431
——— drawn into wire	8878	0,32111			
Braſs caſt	8396	0,30367	White glaſs, French	2892	0,10460
——— in wire	8544	0,30903	Glaſs of S. Gobin	2488	0,09000
Iron caſt	7207	0,26067	Brimſtone	1990	0,07198
——— bar	7788	0,28168	Phoſphorus	1714	0,06199
Steel, ſoft, and not hammered	7840	0,28356	Yellow amber	1078	0,3899
——— hardened	7816	0,28270	Diſtilled water	1000	0,03617
Tin, Engliſh, fuſed	7291	0,26371	Sea water	1026	0,03711
——— hammered	7299	0,26400	Common ſpirit of wine	837	0,03027
Malacca tin fuſed	7296	0,26382	Spirit of wine, the pureſt that can be had by mere diſtillation	820	0,2960
——— hammered	7306	0,26486			
Biſmuth	9823	0,35529			
Nickel	8660	0,31323	Vitriolic ether	739	0,02673
Arſenick, the regulus	5763	0,20844	Nitrous	909	0,03288
Cobalt	7812	0,28255	Marine	730	0,02640
Zinc	7191	0,26009	Acetous	866	0,03132
Antimony	6702	0,24240	Concentrated vitriolic acid	2125	0,07686
Manganeſe	6850	0,24776	——— nitrous acid	1580	0,05714
Wolfran	17600	0,63657	——— marine acid	1194	0,04319
Diamond	3251	0,11759	Fluor acid	1500	0,05425
Ruby	4283	0,15491	Oil of olives	915	0,03309
——— Spinell	3760	0,13600	——— of ſweet almonds	917	0,03316
Topaz, oriental	4011	0,14507	Linſeed oil	940	0,03400
——— Brazillian	3536	0,11718	Naptha	708	0,02561
——— Saxon	3564	0,12891	Gum elaſtic	393	0,03375
Sapphire, oriental	3994	0,14446	Camphor	989	0,03577
Emerald	2775	0,10037	Yellow wax	965	0,03490
Adamantine ſpar	4180	0,15118	White ditto	969	0,03505
Rock cryſtal from Madagaſcar	2653	0,09596	Spermaceti	943	0,03411
Quartz	2654	0,09599	Tallow	942	0,03407
Agate	2590	0,09368	Heart of oak	1170	0,04232
Onyx	2376	0,09537	Cork	240	01868

GREAT WORK. A proceſs for converting or tranſmuting metallic ſubſtances into gold. Chemiſtry poſſeſſes no facts tending to ſhew that any of the metals are convertible into each other; neither do we know of any which evince the abſurdity of ſuppoſing ſuch a converſion to be poſſible. The alchymiſts were doubtleſs miſled, either by the deſire of profit, or by the effect of a few deluſive phenomena, or ſpecious general reaſonings, adapted to the infant ſtate of chemiſtry. Theſe hopes, theſe facts, and theſe reaſonings, have not yet entirely loſt their force with the ignorant. But the ſtrongeſt terms are inſufficient to deſcribe or deplore the ſituation of thoſe who may direct their exertions to a purſuit ſo much calculated to agitate and diſtreſs the mind, and poſſeſſing ſo little probability of ſucceſs as the great work of the alchymiſts.

GRITT-STONE. A ſtone conſiſting of ſand agglutinated together. Its properties differ according to the fineneſs or coarſeneſs of its grain, and the firmneſs of its texture. Some kinds are pounded, to convert them again into ſand; others are uſed for building, others for grinding edge tools, and others for filtering water.

GROWAN. A Corniſh mine term, uſed to denote a compound ſtone, conſiſting of white clay mixed with mica, quartz, and of no particular texture. It is the greiſs of the Germans.

GUHR. A looſe calcareous earth found in the clefts or cavities of rocks, moſtly of a white colour, but ſometimes red or yellow, from a mixture of clay or ochre.

GUM. The mucilage of vegetables. It is uſually tranſparent, more or leſs brittle when dry, though difficultly pulverable; of an inſipid, or ſlightly ſaccharine taſte; ſoluble in, or capable of combining with water in all proportions, to which it gives a gluey adheſive conſiſtence in proportion as its quantity is greater. It is ſeparable, or coagulates by the action of weak acids; inſoluble in ardent ſpirit, or in oil; and capable of the acid fermentation, when diluted with water. The deſtructive action of fire cauſes it to emit much fixed air, and converts it into coal without exhibiting any flame. Diſtillation affords water, acid, a ſmall quantity of oil, a ſmall quantity of volatile alkali, and much coal.

Theſe are the leading properties of gums, rightly ſo called; but the inaccurate cuſtom of former times applied the term gum to all concrete vegetable juices, ſo that in common we hear of gum-copal, gum-ſandarach, and other gums which are either pure reſins, or mixtures of reſins with the vegetable mucilage.

The principal gums are, 1. The common gums, obtained from the plum, the peach, the cherry-tree, &c.—2. Gum Arabic, which flows naturally from the acacia in Egypt, Arabia, and elſewhere. This forms a clear tranſparent mucilage with water.—3. Gum Seneca, or Senegal. It does not greatly differ from gum Arabic: the pieces are larger and clearer; and it ſeems to communicate a higher degree of the adheſive quality to water. It is much uſed by callico-printers and others.—4. Gum Adragant or Tragacanth. It is obtained from a ſmall plant of the ſame name growing in Syria, and other eaſtern parts. It comes to us in ſmall white contorted pieces reſembling worms. It is uſually dearer than other gums, and forms a thicker jelly with water.

Gums treated with a nitrous acid, afford the acid of ſugar.

GUM, ELASTIC. Elaſtic gum is one of thoſe ſubſtances which it is difficult to claſs. It burns like reſins; but its ſoftneſs, its elaſticity, and its inſolubility in the menſtruums which uſually diſſolve reſins, do not allow us to claſs it among thoſe bodies.

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The tree which affords it is known by the name of Seringa, by the Indians of Para. The inhabitants of the province of Eſmeraldas, a province of Quito, call it Hhava; and thoſe of the province of Mainas, Caoutchouc.

Mr. Richard has proved, that this tree is of the family of the euphorbia; and Mr. Dorthes has obſerved that the coccus, which are covered with a down that reſembles ſmall ſtraws, were covered with a gum very much reſembling the elaſtic gum. Theſe inſects feed on the euphorbium; but thoſe which come from other ſituations afford the ſame juice.

We are indebted to Mr. Condamine for an account and accurate details concerning this tree. (Acad. des Sciences, 1751.) This academician informs us, after Mr. Freſneau, engineer at Cayenne, that the caoutchouc is a very lofty tree. Inciſions are made in the bark; and the white juice, which flows out in a more or leſs liquid ſtate, is received in a veſſel placed for that purpoſe. This is applied in ſucceſſive coatings upon a mould of clay, and dried by the fire or in the ſun. All ſorts of deſigns are traced upon it while ſoft; and when it is dry, the clay mould is cruſhed, and the pieces ſhaken out.

This gum is very elaſtic, and capable of great extenſion.

When elaſtic gum is expoſed to the fire, it becomes ſoft, ſwells up, and burns with a white flame. It is uſed for illumination, inſtead of candles, at Cayenne.

It is not at all ſoluble either in water or alcohol. But Macquer has aſſured us, that ether is its true ſolvent; and upon this property he has inſtituted the art of making bougies, for chirurgical uſes, of elaſtic gum, by applying this ſolution upon a mould of wax till it is of the requiſite thickneſs.

Mr. Berniard, to whom we are indebted for important obſervations upon this ſubſtance, found only the nitrous ether, which diſſolved elaſtic gum: very pure vitriolic ether did not perceptibly act upon it.

If elaſtic gum be put in contact with a volatile oil, ſuch as that of turpentine, or even if it be expoſed to the vapour of that fluid, it ſwells, ſoftens, and becomes very paſty. It may then be ſpread upon paper, or applied as a varniſh to cloth; but this covering preſerves its adheſive quality, and does not loſe it for a long time. The mixture of volatile oil and alcohol forms a better ſolvent than the pure oil, and the varniſh dries more ſpeedily.

Mr. Berniard has concluded, from his experiments, that the elaſtic gum is a fat oil, coloured by a matter ſoluble in alcohol, and ſoiled by the ſmoke to which the gum is expoſed while drying.

If linſeed oil be rendered very drying by digeſting it upon the calces of lead, and it be afterwards applied by a ſmall bruſh upon any ſurface, and dried by the ſun, or in the ſmoke, it affords a pellicle of a conſiderable degree of firmneſs, evidently tranſparent, burning like elaſtic gum, and wonderfully elaſtic and diſtenſible. If this very drying oil be left in a wide ſhallow veſſel, the ſurface becomes thick, and forms a membrane which has the greateſt analogy with the elaſtic gum. A pound of this oil ſpread upon a ſtone, and expoſed to the air for ſix or ſeven months, acquired almoſt all the properties of elaſtic gum. It was uſed to make catheters and bougies; was applied to varniſh balloons, &c.

GUM RESIN. Vegetable juices conſiſting of a mixture of gum and reſin, or eſſential oil. Theſe parts do not appear to be in a ſtate of combination, for no menſtruum completely diſſolves the whole. If water be applied, by the aſſiſtance of trituration, the gummy matter is completely diſſolved; and the reſin being ſuſpended in a ſtate of minute diviſion, exhibits the emulſive form.

Ardent ſpirit in like manner takes up the reſinous matter; and the gum, for ſimilar reaſons, gives opacity to the fluid.

Macquer obſerves, that ſince the gum reſins conſiſt of principles not truly combined with each other, the compound muſt be opake; and he therefore lays it down as a rule, that all tranſparent vegetable concretes are either pure gums or pure reſins.

The principal gum reſins are frankincenſe, ſcammony, aſſafœtida, aloes, gum ammoniac, and gamboge.

GUNPOWDER. This well known powder is compoſed of ſeventy-five parts, by weight, of nitre, ſixteen of charcoal, and nine of ſulphur, intimately blended together by long pounding in wooden mortars, with a ſmall quantity of water. This proportion of the materials is the moſt effectual. But the variations of ſtrength in different ſamples of gunpowder are generally occaſioned by the more or leſs intimate diviſion and mixture of the parts. The reaſon of this may be eaſily deduced from the conſideration that nitre does not detonate until in contact with inflammable matter; whence the whole detonation will be more ſpeedy, the more numerous the ſurfaces of contact. The ſame cauſe demands that the ingredients ſhould be very pure, becauſe the mixture of foreign matter not only diminiſhes the quantity of effective ingredients which it repreſents, but likewiſe prevents the contacts by its interpoſition.

The nitre of the third boiling is uſually choſen for making gunpowder, and the charcoal of light woods is preferred to that of thoſe which are heavier, moſt probably becauſe this laſt, being harder, is leſs pulverable. The requiſite pounding of the materials is performed in the large way by a mill, in which wooden mortars are diſpoſed in rows, and in each of which a peſtle is moved by the arbor of a water-wheel: it is neceſſary to moiſten the mixture from time to time with water, which ſerves to prevent its being diſſipated in the pulverulent form, and likewiſe obviates the danger of exploſion from the heat occaſioned by the blows. Twelve hours pounding is in general required to complete the mixture; and when this is done, the gunpowder is in fact made, and only requires to be dried to render it fit for uſe.

There are experiments which ſeem to ſhew, that gunpowder is ſtronger in the fine impalpable form than when granulated. This appears to be true with regard to gunpowder originally made, or pounded until it aſſumes that form; but it may be doubted whether it has any foundation in general, or indeed that the greater ſtrength depends at all upon this form. The granulation of gunpowder is performed by placing the maſs, while in the form of a ſtiff paſte, in a wire ſieve, covering it with a board, and agitating the whole: by this means it is cut into ſmall grains or parts, which, when of a requiſite dryneſs, may be rendered ſmooth or gloſſy by rolling them in a cylindrical veſſel or caſk. Gunpowder in this form takes fire more ſpeedily than if it be afterwards reduced to powder, as may be eaſily accounted for from the circumſtance, that the inflammation is more ſpeedily propagated through the interſtices of the grains. But the proceſs of granulation does itſelf, in all probability, weaken the gunpowder, in the ſame manner as it is weakened by ſuffering it to become damp; for, in this laſt caſe, the nitre, which is the only ſoluble ingredient, ſuffers a partial ſolution in the water, and a ſeparation in cryſtals of greater or leſs magnitude; and accordingly the ſurfaces of contact are rendered leſs numerous.

The detonation of gunpowder has been always an intereſting problem in

chemiſtry. Numerous theories have been offered, to account for this ſtriking fact. But it is now very well ſettled, that the nitrous acid is decompoſed by the heat of ignition; that its vital air combines with the charcoal, and forms fixed air, while the phlogiſticated air, or other component part, becomes diſengaged in the elaſtic form. Berthollet found, that the elaſtic product afforded by the detonation of gunpowder, conſiſted of two parts phlogiſticated air, and one fixed air. The ſudden extraction and expanſion of theſe airs, is the cauſe of the effects of gunpowder. *See* ACID NITROUS.

The marine ſalt afforded by combining the dephlogiſticated or aerated marine acid and vegetable alkali, affords gunpowder of much greater ſtrength than the common nitre. For the method of making this ſalt, *ſee* ACID MARINE AERATED.

GYPSEOUS EARTH, or GYPSUM. A combination of calcareous earth with vitriolic acid. As this ſalt requires about five hundred times its weight of water to diſſolve it, the earlier chemiſts reckon it among the earths. But as its component parts and properties are now well known, gypſum is at preſent conſidered as an earth by chemiſts. *See* EARTH CALCAREOUS.

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HAIR. This animal excreſcence does not appear to differ conſiderably from horn, either in its obvious qualities or component parts. Water or ardent ſpirit have very little action upon it. But acids and alkalis act very ſtrongly, more eſpecially when aſſiſted by heat. The nitrous acid totally diſſolves hair; and if loaded with this ſubſtance by boiling, it depoſits a gelatinous matter on cooling. By repeated abſtraction of nitrous acid, a large proportion of acid of ſugar is obtained. I have not met with an account of the properties of the combination of hair with cauſtic fixed alkali, which diſſolves it.

Neumann examined, by deſtructive diſtillation, the hair of cows, horſes, ſwine, and ſheep, and alſo the human hair. He obtained volatile alkali, partly combined with water, and partly in the concrete ſtate; ſome empyreumatic oil, and a coaly reſidue of difficult incineration, which afforded a ſmall quantity of fixed ſalt. The proportions of theſe in each were different, but need not be here related, as the modern chemiſts would, no doubt, in repeating the experiment, attend to the elaſtic as well as to the condenſible products.

HARDNESS may be defined as that property of bodies by which they reſiſt indentation. It differs from tenacity, which is the oppoſite quality to brittleneſs, whereas hardneſs is the oppoſite quality to ſoftneſs, or the diſpoſition which the parts of a ſolid body poſſeſs of eaſily yielding without fracture. Chemiſts and others uſually aſcertain the comparative hardneſs of bodies by rubbing the one againſt the other; any angular prominence of a harder body being capable of ſcratching or making a mark upon the ſurface of a ſofter. This is not a bad method,

thod, though it may be rendered uncertain by the greater or leſs brittleneſs of the reſpective bodies. Thus hardened ſteel will ſcratch glaſs, and will in return be ſcratched by glaſs; the brittleneſs of the glaſs cauſing it to yield under the ſteel, which is more tenacious, though ſofter. On this principle likewiſe it is that the keeneſt edge tools, and thoſe beſt calculated to cut hard bodies, are not hardened to the higheſt temper the ſteel is capable of, but to ſuch a degree only as to retain much tenacity with a moderate hardneſs.

The mechanical philoſophers, at the beginning of the preſent century, accounted for the hardneſs of bodies, by ſuppoſing their particles to be of ſuch a form as to apply to each other with large ſurfaces of contact. This doctrine ſeems in ſome meaſure to be true, when applied to the cryſtals of bodies on their aſſumption of the ſolid form. Sugar-candy, or the more ſlowly formed cryſtals of ſugar, are harder (or perhaps leſs brittle) than loaf ſugar, in which the ſame ſmall cryſtals are more confuſedly applied to each other: calcareous ſpar is harder than chalk, &c. But how far this doctrine may apply to the hardneſs ariſing from the haſty cryſtalliſation of ſteel and other bodies by immerſion in water, remains to be ſettled by future reſearches.

Mr. Kirwan, in his Mineralogy, has exhibited the hardneſs of the different ſpecies of ſtones, as aſcertained by Mr. Quiſt, by the impreſſion made on each other. In the following table the ſtones, which ſtand firſt, are able to ſcratch or cut the ſucceeding, but not vice verſa; and ſuch ſtones, whoſe hardneſs does not exceed 11, may be ſcratched by ſteel. The firſt column denotes the hardneſs, and the ſecond the ſpecific gravity.

Diamond from Ormos	20			Sardonyx	12	-	2.6
Pink diamond	19	-	3.4	Amethyſt	11	-	2.7
Bluiſh diamond	19	-	3.3	Cryſtal	11	-	2.6
Yellowiſh diamond	19	-	3.3	Carnelion	11	-	2.7
Cubic diamond	18	-	3.2	Green Jaſper	11	-	2.7
Ruby	17	-	4.2	Reddiſh yellow ditto	9	-	2.7
Pale ruby from Brazil	16	-	3.5	Shoerl	10		
Spinell	13	-	3.4	Tourmaline	10		
Deep blue ſapphire	16	-	3.8	Quartz	10	-	2.7
Ditto paler	17	-	3.8	Opal	10	-	2.6
Topaz	15	-	4.2	Chryſolite	10	-	3.7
Whitiſh ditto	14	-	3.5	Zeolyte	8	-	2.1
Bohemian	11	-	2.8	Fluor	7		
Emerald	12	-	2.8	Calcareous Spar	6		
Garnet	12	-	4.4	Gypſum	5		
Agate	12	-	2.6	Chalk	3		
Onyx	12	-	2.4				

HEAT. The ſenſations expreſſed in common language by the words heat and coldneſs, are of too ſimple a nature to require or to admit of definition. Theſe words, however, are not always uſed to denote the ſame things; but are indiſcriminately applied both to the ſenſation itſelf, or to that which cauſes it. Thus, we ſay, that we ourſelves are hot or cold; and that the fire or ice which heats or cools us, is likewiſe hot or cold, though the ſenſations we experience are certainly very different things from that which enables bodies to excite them. It

may alſo be remarked, that, in this ambiguous manner of ſpeaking, there is another cauſe of uncertainty that ariſes from the uſe of a variable ſtandard of compariſon. Every one knows, that the eſtimation of heat or coldneſs differs in various perſons, becauſe each forms his judgment from his own ſenſations; and the ſame body may appear hot to one perſon, and cold to another, or to the ſame perſon at different times; though the variation is not in the body itſelf, but in the ſtate of the perſon in whom theſe ſenſations are excited. Hence it appears neceſſary, in order to avoid error in the purſuit of inquiries concerning heat, that the ſenſe of the words made uſe of ſhould be accurately defined, and that ſome fixed ſtandard of compariſon be made uſe of inſtead of the human body, which, though fixed enough for the common affairs of life, is certainly not enough ſo for the purpoſes of ſcience.

The word heat, in a philoſophical ſenſe, is uſed to denote the cauſe of the power which bodies poſſeſs of exciting the ſenſations of heat or coldneſs.

The word temperature denotes the ſtate of the body with reſpect to that power. So that a body which excites a more intenſe ſenſation of heat or coldneſs than another body, is ſaid to poſſeſs a higher or lower temperature.

It has not yet been determined in what heat itſelf, or the cauſe of temperature, conſiſts. Two opinions have long divided the ſcientific world. One is, that heat conſiſts of a peculiar motion or vibration of the parts of bodies, ſo that the temperature is higher, the ſtronger the vibration. The other is, that heat is a ſubſtance or fluid, whoſe greater or leſs quantity produces a higher or lower temperature. The deciſion of this great queſtion is highly deſerving of the attention of philoſophers. But it will not be neceſſary to conſider its merits in our firſt ſteps of inveſtigation, becauſe the doubts reſpecting it will not impede our reaſoning concerning ſuch phenomena as are well known. For ſince effects are proportioned to their cauſes, we may ſpeak of the quantities of heat in bodies, without deciding whether they be quantities of motion or quantities of matter; the relation of thoſe quantities to each other, and not their peculiar nature, being the chief object of our reſearch.

Two bodies which, when in contact, neither impart nor receive heat from each other, are of the ſame temperature. All bodies, therefore, which by direct or ſucceſſive contact communicate with each other, muſt either have the ſame temperature, or the hotter will communicate heat to the others, till a common temperature is produced amongſt them.

The diſpoſition or power of quickly tranſmitting heat in the production of a common temperature, is not the ſame in different bodies. If a number of ſtraight wires of equal ſizes, but different metals, be covered each with a thin coat of wax, and their ends be plunged in the ſame heated fluid, for example, melted lead, the fuſion of the coat of wax will ſhew that heat is more quickly tranſmitted through ſome metals than others. Thus alſo it is found, that the end of a glaſs rod may be kept red hot for a very long time, without any inconvenience to the hand which holds the other end; though a ſimilar metallic rod, heated in the ſame manner, would very ſoon become too hot to be held. Bodies that quickly alter their temperature by communication, are ſaid to be better conductors of heat than ſuch as alter more ſlowly.

The general effects of a change of temperature are theſe: A ſolid is rendered fluid by an increaſe of temperature, and a ſtill greater increaſe converts it into elaſtic fluid or vapour. If the body be compoſed of parts, which become ſolid,

fluid, or vaporous, at different temperatures; and the elective attraction, by which thoſe parts are held together, be inſufficient to prevent their aſſuming theſe ſtates by the change of temperature, a ſeparation will then take place: thus a diminiſhed temperature ſeparates ſalt from water, by their becoming ſolid; and an increaſed temperature ſeparates water from ſalts, by cauſing the former to fly off in vapour. Laſtly, if neither the change of temperature be conſiderable enough to alter the ſtate of ſolidity, fluidity, or vapour which the body under conſideration may happen to poſſeſs, nor the body itſelf be of the nature to undergo a ſeparation of its parts by the change, then an increaſe of temperature will cauſe an increaſe in the bulk or dimenſions of the body, which will laſt no longer than during the time of the increaſe.

It has already been obſerved, that the temperature at which different bodies change their form is various. Neither this property, nor the expanſions of bodies by heat, have been obſerved to have any correſpondence with their denſity, hardneſs, ſpecific gravity, or other evident properties. There are, likewiſe, ſome irregularities in the contraction or expanſion, which depend on circumſtances not yet well aſcertained, near the freezing point, of water, and probably other ſubſtances. Pure water, when cooled, is obſerved to contract till within about eight degrees of the freezing temperature, where it begins to expand; and it may be cooled eleven degrees below that temperature, and ſtill continue fluid. An adequate explanation of the circumſtances that attend the converſion of bodies from their ſeveral ſtates of ſolidity, fluidity, and vapour, ſeems to promiſe a more intimate acquaintance with the nature and properties of the particles of bodies, than has hitherto been obtained.

Permanently elaſtic fluids, or airs, appear to differ from vapour in the circumſtance, that they take and retain the elaſtic form at a lower temperature. There are facts which render it probable, from analogy, that a great degree of cold would convert them into denſe fluids.

It is a ſelf-evident truth, that, if two bodies be perfectly equal and alike in all reſpects, and have the ſame temperature, they will poſſeſs equal quantities of heat.

Thus, a pound of gold will poſſeſs an equal quantity of heat with another pound of gold at the ſame temperature, a pound of water will poſſeſs an equal quantity of heat with another pound of water at the ſame temperature, and ſo forth. From this it will alſo be clear, that two pounds of gold will poſſeſs twice as much heat as one pound of gold, at the ſame temperature; and generally, that the quantities of heat in bodies of the ſame kind, and at the ſame temperature, will be in proportion to their quantities of matter, or their weights.

If two ſuch equal and ſimilar bodies, that differ in temperature, be brought together, they will, by communication, acquire a common temperature, and their quantities of heat will by that means be rendered equal. For this purpoſe, it is clear, that the hotter of the two bodies muſt have communicated half its exceſs to the colder. The quantity of heat in one of the two equal bodies will therefore be an arithmetical mean between the two quantities originally poſſeſſed by each of them; that is to ſay, its temperature, or the common temperature, will exceed that of the colder exactly as much as it falls ſhort of the hotter bodies.

If the two bodies had been unequal, they would nevertheleſs have acquired a common temperature by communication; but the exceſs of heat would not have been equally divided between them. For we have ſhewn, that the quantities of heat in ſuch bodies, at the ſame temperature, are in proportion to the quantities

of

of matter. If the ſurplus of heat had been entirely taken away, it is obvious, that their temperature would have been made equal, and their heats would have been in that proportion; and there is no other way of adding the ſurplus to them, ſo as to preſerve the ſame proportion, but by giving more to the larger than to the ſmaller body, according to its quantity. The common temperature that they acquire ſhews that this is done; and conſequently, that, when two unequal bodies of the ſame kind acquire a common temperature by communication, the exceſs of heat in the hotter body is divided between them in proportion to their weights or quantities of matter.

From this it is likewiſe evident, that the quantities of heat required to be added to or taken from bodies of the ſame kind, to produce equal changes in their temperature, will be in proportion to their quantities of matter.

The foregoing deductions naturally lead us to the conſideration of an inſtrument proper to ſhow the temperatures of bodies. Such an inſtrument will require to be placed in contact with the body under examination, in order that it may acquire the ſame temperature. It is therefore an indiſpenſable condition, that the inſtrument ſhould be of that ſmall bulk as not ſenſibly to heat or cool the body it touches; but that the common temperature of the inſtrument, and the body itſelf upon contact, may, without perceptible error, be taken for the original temperature of the body. Another condition equally requiſite is, that every change of temperature ſhall be attended with ſome evident change in the inſtrument by which it may be aſcertained. The expanſions and contractions of bodies are the moſt convenient for this purpoſe. Theſe, however, are ſmall, and would require to be magnified by ſome mechanical or optical contrivance, if a ſolid body were made uſe of. But the ſmalleſt change in the bulks of fluids may be eaſily ſhown, by the happy expedient of including them in a bottle, whoſe neck is long and very narrow in proportion to the diameter of its body. On theſe conſiderations the thermometer is made. It conſiſts of a glaſs ball or bottle with a long narrow tube or neck, and is partly filled with mercury, a fluid preferable to all others, from its unchangeableneſs, the regularity of its expanſions, and its not ſoiling the tube. The expanſions or contractions of the mercury are ſhewn by the riſe or fall of its ſurface, which is meaſured by a graduated ſcale uſually fixed to the tube. *See* THERMOMETER.

The determination of the correſpondence between the degrees of the thermometer, and the actual variations of the heats of fluids, was firſt accurately determined by Mr. de Luc. By mixing equal quantities of water at different temperatures, he found that the thermometer very nearly indicated the arithmetical mean between the two temperatures, and conſequently that its indications are ſuch as truly correſpond with the qualities of heat.

As theſe fundamental experiments cannot be too ſtrictly examined, the following doubt remained to be conſidered, namely, whether the diſpoſition to give out or to receive heat, were the ſame in water at all temperatures? becauſe it is clear, that if this diſpoſition be changed by heating or cooling, the temperature, or power to heat or cool other bodies, will not follow the ſame proportion as the quantities of heat; though it may be imagined, not without probability in this caſe, that correſpondent irregularities in the expanſions of the mercury may cauſe the thermometer to indicate the arithmetical means between the two expanſions produced by an extreme temperature. But whatever irregularities may be ſuppoſed to counteract each other in theſe experiments with mercury and water, it is to the laſt degree improbable that the ſame compenſation would

would be found, when the mean temperature is obtained by other methods. With this view, the celebrated Dr. Crawford* very carefully repeated and confirmed Mr. de Luc's experiments, made others with a like reſult, by uſing lint-ſeed oil inſtead of water, and alſo by producing the mean temperature permanently in air included in a cylinder formed of two equal parts, the upper of which was kept to the freezing point, by ſurrounding it with pounded ice, and the lower to the boiling water point, by ſurrounding it with a greater ſupply of ſteam than could be condenſed by its contact. The near correſpondence of theſe ſeveral methods, that the expanſions of mercury in the thermometer are correſpondent with the heat it receives.

Thus far we have attended only to the communication of heat between bodies of the ſame kind; but when two equal bodies of different kinds produce a common temperature by communication, it ſeldom happens that it proves to be an arithmetical mean between the two original temperatures. In ſuch caſes, it is evident, that the heat, which was communicated from one to the other, has not altered their temperatures equally, but has raiſed or lowered that of the one more than it has lowered or raiſed that of the other. And as the proportion between the number of degrees through which one of the two bodies is thus raiſed, and the other lowered, is found, by experiment, to be the ſame, however different the two original temperatures may have been, provided no change of form or chemical combination has been produced in either of them; it is a general conſequence, that the quantity of heat required to alter the temperature of one of the bodies a ſingle degree, or any other equal part, will be greater or leſs than would be required to produce the ſame change in the other body, in proportion as the changes produced by the communicated heat were leſs or greater.

The whole heat in each body, when they have the ſame temperature, muſt conſiſt of the ſame number of degrees: the proportion between the whole heats of the bodies will, therefore, be the ſame as between the heats required to raiſe each of them a ſingle degree: that is to ſay, the comparative heats of bodies, at the ſame temperature, will be in the inverſe proportion of the number of degrees their temperature is altered by the tranſmiſſion of the ſame quantity of heat.

To illuſtrate this by an example in round numbers: Suppoſe a pint of mercury, at the temperature of 136°, be mixed with a pint of water at 50°, the mean temperature will be 76°. The water, therefore, has been heated 26°, and the mercury has been cooled 60°, by the loſs of the heat it imparted to the water. The abſolute heat in one degree of the mercury will, conſequently, be proportionally leſs than that of one degree of the water; becauſe the very ſame heat, which has raiſed the water 26° in temperature, would raiſe the mercury 60, if it could be returned again; and the whole heat contained in the mercury will be to that of the water in the ſame proportion of 26 to 60. But, in the preſent experiment, equal bulks were uſed; and mercury is about thirteen times as heavy as water; and equal weights of mercury would contain only one thirteenth part of the heat. Twenty-ſix, divided by 13, quotes 2. Whence the comparative heats of mercury and water are in the proportion of about 2 to 60, or 1 to 30; that is to ſay, a pound of mercury, at the ſame temperature, contains no more than one thirteenth part of the heat contained in a pound of water.

* On Heat. London, 1788. This valuable performance contains the theory and moſt of the facts relating to heat, and deſerves to be made a part of the library of every natural philoſopher.

It may be obſerved, that the term comparative heat is uſed to denote the proportion of the abſolute quantity of heat in one body to that of another equal maſs of matter at the ſame temperature, conſidered as a ſtandard. The ſtandard made uſe of is pure water in a fluid ſtate. Some writers call this ſpecific heat. The diſpoſition or property by which bodies ſeverally require more or leſs heat to produce equal changes in their temperature, is called their capacity for heat. Theſe capacities are conſidered as the unknown cauſe of the difference in their comparative heats, to which they are conſequently proportional.

It is found by experiment, that the capacity of the ſame body for heat is leaſt when ſolid, greater when fuſed or fluid, and greateſt of all when it becomes converted into vapour, or elaſtic fluid.

Alſo, when bodies unite by virtue of chemical attraction, their capacities are ſeldom the ſame as the ſum of the capacities of the bodies, but almoſt always either greater or leſs.

As the experiments relating to the capacities of bodies cannot be here given at large, it will be proper to mention, by way of inference, ſome of the chief conſequences of this moſt luminous doctrine; firſt premiſing, however, that theſe inductions have all been verified by experiment *.

The capacities of ice and fluid water are found to be as 9 to 10. Ice cannot, therefore, be converted into water, unleſs it be ſupplied with as much heat as is ſufficient to anſwer the difference of capacity. Thus, if equal quantities of ice and water, both at the temperature of 32°, or the freezing point, be expoſed in ſimilar veſſels, at the ſame diſtance from a fire, both will receive heat alike, and the ice will be melted into water at 32°, while the water in the other veſſel will have its temperature raiſed to 178°. Here it is obvious, that the ſame heat which raiſed the water to 146°, was merely ſufficient to ſupply the increaſed capacity of the ice; for which reaſon this laſt had not its temperature raiſed at all. If the experiment be more accurately made, by mixing equal weights of water at 178° and ice at 32°, the ſame conſequence will follow; for the ice will be melted, and the common temperature will be 32°; becauſe the ice in melting receives no augmentation of temperature by abſorbing the whole 146° of heat from the water, by virtue of its increaſed capacity when it becomes fluid.

And ſo, likewiſe, when water is frozen by the loſs of its heat, communicated to a cold atmoſphere or other contiguous bodies, the proceſs of cooling goes on till ice begins to be formed; but during the whole time of the converſion of the water into ice, the temperature remains ſtationary, becauſe the diminiſhed capacity of the ice cauſes it to give out heat, the continual evolution of which ſupplies the refrigerating bodies with as much as their energy of cooling might otherwiſe have taken to cauſe a diminution of the temperature. When the whole is frozen, this ſupply of extricated heat ceaſes; and therefore the cauſe, that cooled the water at firſt, goes on in cooling the ice, till the common temperature is produced.

In all experiments, wherein the capacities of the ſame bodies are changed, and the difference between the quantities of heat in the ſame body, in both ſtates, at one common temperature, is known in the degrees of the thermometer, we may derive the advantage of finding the abſolute quantities of heat in degrees of the thermometer, or the number of degrees which any particular point or temperature is remote from the true zero, or point of abſolute privation of all heat.

* For which conſult Dr. Crawford's Treatiſe, already ſpoken of.

To illuſtrate this curious poſition, the experiments on ice and water, juſt related, may be made uſe of. The whole quantities of heat, in theſe two ſtates, are as 9 to 10. It is plain, therefore, when water freezes, it muſt give out one-tenth of its whole heat; and this tenth part, by the experiment, is found to amount to 146° of Fahrenheit's thermometer; conſequently its whole heat is ten times 146°, or 1460°; when its temperature is 32° above Fahrenheit's zero. Whence the natural zero is at 1428°.

No direct experiment has yet been made to ſhew the capacity of ſteam with relation to water. An indirect experiment of Dr. Crawford makes it as $15\frac{1}{2}$ to 10*. It is accordingly found, that ſteam, in its condenſation into water, gives out as much heat as would raiſe the temperature of an equal quantity of non-evaporable matter, of the ſame capacity as water, 914 degrees. This heat it muſt have taken up at its formation. Whenever water is heated, we may, conſequently, conſider the heat as diſpoſed of in two ways. Part raiſes the temperature, and part is employed in ſupplying the elaſtic vapour which flies off with the heat its increaſed capacity requires at that temperature. The greater the quantity of ſteam, the larger will be the proportion of heat employed in this laſt way. Now it is found, that a difficulty attends the production of ſteam, in proportion as effective obſtacles are oppoſed in the way of its expanſion or eſcape. If the water be heated in a cloſe veſſel, ſuch as the Digeſter of Papin, no ſteam will be formed; if there be a ſmall hole for the ſteam to eſcape, there will be leſs formed than if the whole ſurface of the fluid were uncovered; and if the ſuperincumbent atmoſphere be removed, as in the vacuum of an air pump, the production will be greateſt of all. In every caſe where the ſteam can eſcape, it will be produced, until the quantity of heat employed in forming the elaſtic ſtate has become equal to the ſupply of heat communicated to the fluid it eſcapes from. At this period, the temperature of the fluid will become invariable, but the quantity of ſteam thrown off will, in like circumſtances, be proportioned to the facility of its eſcape. The ſtationary heat of the fluid will be governed, not by the heat applied, but by the ſame facility of eſcape. Water in the open air boils violently, and acquires a fixed temperature at 212° of Fahrenheit. But this varies a little, as the weight of the air varies and oppoſes a different reſiſtance to the ſteam. *See* THERMOMETER. It has been ſtated, and with ſome probability, that there would be no interval of fluidity between the ſolid and the vaporous ſtates, if it were not for the preſſure of the atmoſphere.

From this principle of the enlarged capacity of vapour, it is eaſy to account for the cold produced by evaporation. Every one is acquainted with the cold produced by wetting the hand with water, and, ſtill more, with ſpirits of wine. The hand is the ſource of heat to the water, and would raiſe its temperature to 95°, if no evaporation took place. But as the water flies off in ſteam, the ſtationary temperature is produced at a lower degree, for the reaſons juſt mentioned. The hand muſt therefore receive the ſenſation of cold from the water which envelops it, and this ſenſation will continue till it is all evaporated.

Spirit of wine or ether, being more evaporable, have their ſtationary point of temperature lower than water in ſimilar circumſtances of expoſure. The freezing of water by means of ether affords a ſtriking inſtance of this effect. Water is included in a thin glaſs tube, and the outſide of the tube is kept continually wetted with ether, by means of a bottle with a capillary tube in its neck,

* Crawford on Animal Heat, p. 270.

through which the ether is poured. The conſequence of the ſpeedy evaporation of this very volatile fluid is, that in a very ſhort time the included water is ſuddenly converted into ice, even before a fire, or in the midſt of ſummer.

There appears to be no difficulty in accounting for the cold produced by the evaporation of water from the ſurface of the hand; becauſe it is perfectly analogous to the fact where a ſtationary temperature, or boiling point, is produced over a fire. But in the experiment with ether it may ſeem remarkable, that the refrigeration is carried to a point ſo far beneath that of every one of the ſurrounding bodies. This may, however, be explained from an attention to what is obſerved to happen with water. If water were incloſed in a ſtrong metallic veſſel, and ſurrounded on all ſides with ignited coals, there is no doubt, from the general courſe of facts, but that it would become gradually hotter, until it either burſt the veſſel by its expanſive force, or acquired a temperature equal to that of the coals. But if an hole be ſuddenly opened, after the temperature has increaſed beyond the common boiling-water point, it is found that a ſudden extrication of ſteam takes place, and the fluid immediately falls to the temperature of boiling water. Now the ether, being much more volatile than water, may be conſidered, when confined in a bottle, to be in a ſtate ſimilar to that of water in Papin's Digeſter; and the ſurrounding bodies act upon the bottle like the coals in the former inſtance. The included ether acquires the common temperature, becauſe it is prevented from aſſuming the vaporous ſtate, and has not elaſticity enough to break the veſſel. But as ſoon as this fluid is ſet at liberty, it evaporates readily, and becomes cooled down towards a ſtationary degree of temperature; at which if acquired, the heat carried off by the vapour would be accurately equal to that ſupplied by the ſurrounding bodies. This temperature, at the ſurface of ether expoſed in our climate, is, on account of its volatility, conſiderably below the freezing point of water; and therefore, whenever a thin ſtratum of ether is made to ſurround a ſmall veſſel of water, it is no wonder it robs it of ſo much heat as to congeal it in a ſhort time.

The effect of freezing mixtures is another evident conſequence of this doctrine of the change of capacities of bodies for heat. When common ſalt is added to water, in as large a quantity as can be diſſolved, the brine is much more difficult of congelation than mere water; ſo much ſo, that it does not acquire the ſolid ſtate until it is cooled as low as, 6° below 0° on Fahrenheit's ſcale; or 38° below the freezing point of water. Suppoſe now, that the ſalt be mixed, not with water, but with ſnow, or pounded ice. Theſe two ſubſtances will be diſpoſed to combine together as before, but much of the effect will depend on the temperature. If this be ſo low, as that the combination may preſerve the ſolid ſtate, the external parts in contact of each will indeed unite; but they will form a ſolid combination, that will effectually prevent the internal parts from approaching each other, and accordingly little or no perceptible progreſs will be made towards the union of the whole maſs. But if, on the contrary, the temperature be higher than this, the combination will be the fluid brine, though the ſnow and ice were ſolid before; and this for the plain reaſon, that the brine requires a leſs heat to fuſe it, than would have been requiſite to fuſe the ice alone. The aſſumption of the fluid ſtate in theſe bodies will increaſe their capacity, and they will be diſpoſed to deprive the ſurrounding bodies of heat; that is to ſay, they will be colder than before. If the quantity of ſnow and ſalt be conſiderable, and there be no bodies at hand which can readily ſupply the heats required, the brine firſt produced will cool the ſnow and ſalt in its vicinity; and theſe, when

liquefied, will cool the reſt of the ſnow and ſalt ſtill more effectually. When the temperature of the whole is by this proceſs reduced as low as—6°, or the freezing point of the brine, the liquefaction will ſtop, or it will proceed more ſlowly or faſter, in proportion as the requiſite heat can be ſupplied. It may therefore be eaſily underſtood, that if a mixture of this kind be placed in a veſſel, and a ſmaller veſſel containing water be plunged in it, the cooling proceſs will freeze the water. It is likewiſe evident, that ſuch mixtures can deſcend in temperature no lower than a certain fixed degree, which is their own freezing point *.

There are other freezing proceſſes effected by the mere liquefaction or ſolution of ſalts in water, which alſo appear to depend on the increaſed capacity of the ſalt, or more probably of the water contained in them †. Among a variety of proceſſes of this kind deſcribed in the Philoſophical Tranſactions, the following may be ſelected, not as the moſt powerful, but becauſe the materials are cheap, and well known. Equal parts of ſaltpetre and ſal-ammoniac are to be reduced to a fine powder. If four ounces of water be poured on three ounces of this mixture, the ſolution will ſink the thermometer 36 degrees: and as it is eaſy in this country to have pump water, at any ſeaſon, as cool as 50°, this addition will cool it to 14°, which is therefore ſufficient to freeze water in a phial plunged in it. If the water cooled in a firſt proceſs be uſed to reduce other water and ſalts to the temperature of about 32°, and theſe be applied to the performance of a ſecond proceſs, the temperature will be much lower, viz. 4° below 0°.

Without entering more largely into examples of the change of capacity for heat in bodies which are changed in their form or ſtate of chemical combination, it may be obſerved in general, that as the powers of gravity and projection, in continual oppoſition to each other, produce all the varied effects of poſition, and its conſequences, in the great ſyſtem to which they are eſſential; ſo among the actions of the minute parts of bodies, the coheſive attraction and the energy of heat are in continual oppoſition, and are concerned in every proceſs of change in their peculiar properties. It is certain, that the particles of bodies do not touch each other, but are held in equilibrio at a certain diſtance, which varies with the temperature, as is deduced from the expanſions and contractions dependant on this cauſe. What might be the conſequences of an extreme depreſſion of temperature, we are not likely ever to diſcover, and conjecture leads us very little in the doctrine of heat. It may be obſerved, that the changes of capacity in bodies, when they take the ſolid, fluid, or vaporous ſtate, are greatly conducive to the preſervation of a more equal temperature, than would otherwiſe be found in the diſtricts around us. The cold produced by evaporation mitigates and conducts to other parts the ſtrong heats of the torrid zone, and the heat developed on the freezing of water prevents the cold countries from being cooled as far below the freezing point as might otherwiſe happen. If the capacities of water and ice were equal, the freezing of immenſe bodies of water would ſcarcely be progreſſive, but would take place the inſtant the whole was cooled to 32°; and ſo likewiſe the thawing of immenſe bodies of ſnow, and of mountains of ice, would be performed in the ſhort time of the tranſmiſſion of heat requiſite to elevate its temperature the minuteſt portion of a degree above the temperature of ſolidity.

* Crawford, p. 474.
† Walker, in Philoſ. Tranſ. vol. lxxvii and lxxviii.

There are various methods uſed to increaſe the temperature of bodies. The friction of two pieces of wood againſt each other in a turner's lath produces heat and flame. A nail may be made red hot by quickly hammering it, or by the action of a dry grindſtone; and when flint and ſteel are ſtruck together, ſmall particles of the ſteel are ſeparated, which are in a ſtrong ſtate of deflagration; and upon examination with the microſcope are found to have been fuſed into hollow greyiſh balls. From theſe facts it appears, that as heat increaſes the dimenſions of bodies, ſo the diminution of the magnitude of bodies by mechanical action, cauſes them to give out heat, which if ſuddenly extricated will even produce a ſtrong ſtate of ignition. The ſun's light, concentrated by a lens or mirror, is found to produce the moſt aſtoniſhing effects, by raiſing the temperature of bodies; as does likewiſe the electric ſhock, both of which far exceed thoſe of our furnaces. Many chemical mixtures, wherein a rapid combination and change of capacity take place, produce ignition and flame. But the operations of chemiſtry, and the arts that require an increaſe of temperature, are generally performed by the contact of bodies in a ſtate of combuſtion. See COMBUSTION, AIR VITAL, and PHLOGISTON.

Light and heat differ from each other in their chemical effects, as many experiments ſhew. The heat produced in the focus of a mirror or lens is not exactly in proportion to the quantity of light, but in ſome meaſure depends on its direction; ſo that the ſame quantity of light at the focus, ſpread over an equal ſurface, will heat more than if either within or beyond it. Part of the heat of a fire, though not luminous, is thrown off in rays ſubject to the ſame laws of reflection as light, but not like it tranſmitted through glaſs. This is plainly ſhewn by interpoſing a pane of glaſs between a fire and the face of an obſerver. The light will paſs through, but the heat will be intercepted, and will be employed in raiſing the temperature of the glaſs*. And accordingly the heat of the fire will not be increaſed in the focus of a ſpeculum of glaſs, though a metallic ſpeculum will produce a great effect. A bright table ſpoon may be uſed for this experiment, inſtead of a mirror. If two metallic concave ſpeculums be ſo placed at a diſtance from each other, that their axis may coincide, and an iron heated below ignition be placed in the focus (of parallel rays) of one mirror, there will be an image of the iron formed in the focus of the other; at which if a thermometer be applied, its temperature will be raiſed. Whence it follows, that the heat radiating inviſibly from the iron is governed by the ſame laws as the light which forms the image. It is likewiſe found, that a freezing mixture †, placed in the ſame ſituation, will depreſs the thermometer by the action of its focal image. This has been thought to evince the material nature of cold, which has in every theory been ſuppoſed to be the mere negation of heat. It does not, however, appear to prove any thing more, than that, in the preſent conſtitution of the world, heat is emitted in all directions by all bodies; and that the freezing mixture intercepts a portion, which would have paſſed through the focus of one mirror, and proceeded to the other. The freezing mixture does the ſame thing as to the heat, which a black ſubſtance would have effected with regard to light. A black ſubſtance in one focus would have been viſible in the other; not by the emiſſion of rays of darkneſs, but by the interruption and privation of as much light as would elſe have proceeded from its apparent place. See LIGHT.

* Scheele on Air and Fire, p. 70. Eng. tranſlation.
† By M. Pictet, but I forget where mentioned.

Whether

Whether heat be matter or motion, is a queſtion which has not yet been well ſettled. If heat be nothing more than an inteſtine or vibratory motion of the particles of bodies, its communication, or tranſmiſſion, may be eaſily explained, and with much ſimplicity, from the general laws of motion. But its abſorption and extrication in the phenomena of freezing, or combuſtion, in the latter of which a ſingle ſpark of ignited matter may produce the moſt violent conflagration through an extenſive town, do not ſeem to be as eaſily accounted for by the laws of motion, without hypothetical aſſumptions, as by the ſuppoſition of a peculiar matter called heat. It may, perhaps, be ſufficient on this ſubject to obſerve, that the effects of heat will not eaſily admit of compariſon or analogy with any of the other appearances in nature; but can only be examined by experimental reſearch.

Attempts have been made to determine whether the weight of bodies is affected by the greater or leſs quantity of heat they may contain. Dr. George Fordyce * weighed about 1700 grains of water in a bottle hermetically ſealed, when unfrozen, at the temperature of 32°, and in a room wherein the air was of the ſame temperature. The water being then frozen, was found to be near one ſixteenth of a grain heavier. Sir Benjamin Thompſon obtained the ſame concluſion, by counterpoiſing water againſt ſpirit of wine, and expoſing the apparatus to a cold atmoſphere, which froze the former. In this laſt experiment the only apparent cauſe of error ſeems to be, that the water might not at firſt be cooled ſo low as the ſpirit, in which caſe an aſcending current of air might have rendered the water more buoyant. But this error, if it exiſted, tends to confirm the concluſion in which the water preponderated.

Hence it is ſeen, that heat diminiſhes the attraction of gravity, as it alſo does that of coheſion, and probably thoſe obſerved in chemiſtry, though its operation in producing the fluid ſtate is ſo favourable to combination, as to render the obſervation of this laſt effect difficult. Whether the operation of heat in the diminution of the power of gravity may have any perceptible effect in enlarging the diſtances and periodical times of the inferior planets, muſt be left to the determination of aſtronomers.

Here follows a table of the comparative heats, or capacities of bodies for heat, extracted from Dr. Crawford's work. In this table, the capacity of water is uſed as the ſtandard of compariſon or unity. The numbers will therefore denote the whole quantities of heat in equal weights of the ſeveral bodies reſpectively at like temperatures, admitting that the capacities remain unchanged at all temperatures; or they will denote the relative quantities of heat required to cauſe equal changes in the temperature of ſuch bodies; and hence the changes of temperature cauſed by the loſs or gain of equal quantities of heat will be inverſely as thoſe numbers.

TABLE.

The Comparative Heats of Different Bodies.

Inflammable air	21,4000	Arterial blood	1,0300
Dephlogiſticated air	4,7490	Water	1,0000
Atmoſpherical air	1,7900	Freſh milk of a cow	,9999
Aqueous vapour	1,5500	Venous blood	,8928
Fixed air	1,0454	Phlogiſticated air	,7936

* Phil. Tranſ. lxxv. p. 362.

Hide

Hide of an ox with the hair -	,7870	Cinders - -	,1925
Lungs of a ſheep - -	,7690	Aſhes of cinders - -	,1855
Lean of the beef of an ox -	,7400	Ruſt of iron, nearly freed from air - -	,1666
Alcohol - -	,6021	Waſhed diaphoretic antimony, nearly freed from air -	,1666
Rice - - -	,5060	Aſhes of the elm tree -	,1402
Horſe beans - -	,5020	Calx of zinc, nearly freed from air - - -	,1369
Spermaceti oil - -	,5000	Iron - - -	,1269
Duſt of the pine tree -	,5000	Braſs - - -	,1123
Peas - - -	,4920	Copper - -	,1111
Wheat - -	,4770	White calx of tin, nearly freed from air - -	,0990
Barley - -	,4210	Regulus of zinc - -	,0943
Oats - -	,4160	Aſhes of charcoal -	,0909
Vitriolic acid - -	,4290	Tin - -	,0704
Pit coal - -	,2777	Yellow calx of lead, nearly freed from air -	,0680
Charcoal - -	,2631	Regulus of antimony -	,0645
Chalk - -	,2564	Lead - -	,0352
Ruſt of iron - -	,2500		
Waſhed diaphoretic antimony	,2272		
Calx of copper, nearly freed from air - -	,2272		
Quicklime - -	,2229		

HEDERÆ, GUM. Lemery ſays, that this gum exſudes from inciſions made in the hedera arborea, or tree ivy, whence it is collected by the peaſants in Italy, Provence, and Languedoc. The account is confirmed by Pomet; but Neumann, from unſucceſsful enquiries made on his own travels, is diſpoſed to conſider the account as doubtful, though he learned that it was the produce of Sicily and the kingdom of Naples.

This gum reſin, when genuine, is of a bright tranſparent reddiſh brown colour, deeper than the hyacinth, and approaching to the garnet; when reduced to powder, of a ſaffron yellow, and of an agreeable aromatic taſte and ſmell. From an ounce of this, Neumann obtained five drams and a half of reſinous extract by ſolution in ardent ſpirit, and of the reſidue water took up half a dram, and left two drams of inſoluble reſidue. When water was applied firſt to another ounce, it took up two drams of gummy matter, and of the reſidue ſpirit diſſolved three drams two ſcruples, and left two drams and half a ſcruple undiſſolved. By diſtillation with ardent ſpirit, the fluid came over with a ſlight taſte of the gum reſin. Water diſtilled from the hederæ was conſiderably impregnated both with the taſte and ſmell, and brought over a ſmall quantity of eſſential oil, leſs hot to the taſte than other oils of that claſs.

HELIOTROPIUM. The dyers uſe a blue paſte under the name of Litmus, which is ſuppoſed to be prepared from the heliotropium tricoceum, which grows wild about Montpellier. According to M. Niſſole of the French Academy, quoted by Savary in his Dictionnaire de Commerce, the colouring juice is obtained from the tops of the plant, gathered in Auguſt, ground in mills, and then committed to the preſs. The juice is expoſed to the ſun for about an hour; rags are then dipped in it, dried in the ſun, moiſtened by the vapour which ariſes from the ſlaking of quick lime with urine, then dried again in the ſun, and dipped again in the juice. The Dutch and others are ſaid to prepare turnſole rags,

rags, and turnſole in the maſs, from different ingredients, of which archil is the chief. *See* ARCHIL.

The account of the rags or cloth of turnſole, as given by Chaptal *, ſtates, that they are prepared by impregnating them with the juice of *morelle*, and expoſing them to the vapour of urine, which develops their blue colour. Theſe rags are exported to Holland, not for the uſe of the makers of turnſole, as is commonly ſuppoſed, but for the dealers in cheeſe, who extract a colour by infuſion, and waſh their cheeſes with it to give them a red colour. He was convinced by experiment, that the colouring matter of the turnſole paſte is of the ſame nature as that of archil; and found that by cauſing the lichen parellus of Auvergne to ferment with urine, lime, and alkali, he could obtain a paſte ſimilar to that of turnſole. The addition of alkali appears to be neceſſary to prevent the development of the red colour, which, when combined with the blue, forms the violet of the archil.

The attention of chemiſts is more particularly directed to this ſubſtance, on account of its affording one of the moſt uſual teſts of the preſence of acidity. The tincture of turnſole is prepared by lightly infuſing the turnſole or litmus in water. If the water be too highly charged with the colouring matter, the infuſion has a violet tinge, and muſt in that caſe be diluted with water until it becomes blue. Expoſure of this infuſion to the ſun, even in cloſed veſſels, turns it red, and ſome time afterwards the coloured matter falls down in the form of a diſcoloured mucilage. Ardent ſpirit may be uſed inſtead of water in this preparation.

It is ſcarcely requiſite to direct the intelligent beginner in the uſe of this and other teſts. Paper may be ſtained with it, and a drop of the ſuppoſed acid will turn it red. Or the liquids may be mixed in greater or leſs quantities, as convenient. This blue liquor may be made a teſt for alkalis, if it be firſt reddened by the addition of a ſmall portion of vinegar or other acid. Alkalis reſtore the blue colour.

For another teſt, *ſee* BRASSICA RUBRA.

HELLEBORE. Two ounces of the root of white hellebore yielded with water nine drams and one ſcruple of gummy extract; and the ſame quantity of root yielded with ſpirit of wine ſeven drams of reſinous extract. From ſix ounces of the roots of black hellebore, ſix drams and one ſcruple were extracted by ſpirit; and from the ſame quantity of root, ſix drams and two grains were extracted by water. Borrichius relates, that the diſtilled water of the entire plant poſſeſſes emetic and purgative virtues. The root is a ſtimulating cathartic. Neumann.

HEPAR. The combination of ſulphur with an alkali was denominated Hepar Sulphuris, or Liver of Sulphur, from its brown-red colour. Chemiſts have applied the term *hepar* in a general way to all combinations of alkali or earth with ſulphur, or with phoſphorus. *See* SULPHUR, PHOSPHORUS, AIR HEPATIC, AIR PHOSPHORIC.

HEPATIC AIR. *See* AIR HEPATIC.

HOMBERG's PHOSPHORUS. The combination of lime and marine acid, which remains after diſtilling the volatile alkali from ſal ammoniac, has uſually an over-proportion of lime. If it be urged by a violent heat it fuſes; and when cold it has the property of emitting a phoſphoric light when ſtruck with any

* Chemiſtry, i. 190.

hard

hard body. It is called Homberg's phoſphorus, from the name of the firſt obſerver of the fact.

HONEY. Honey is contained chiefly in the baſe of the piſtil or female organ of flowers. It ſerves as food for moſt inſects which have a proboſcis. It appears to conſiſt of ſugar, mucilage, and water. The ſugar ſometimes ſeparates in cryſtals.

Honey is ſuppoſed to have undergone no alteration in the body of the bee, as it retains the odour, and not unfrequently the qualities, of the plants it was gathered from.

Thirty-ſix ounces of honey diluted with four quarts of warm-water, and fermented with a little yeaſt, yielded on diſtillation a pint of watery ſpirit, which by rectification was reduced to eight ounces.

HOOFS OF ANIMALS. The hoofs of animals are compoſed of a ſubſtance nearly of the ſame nature as HORN, which ſee. They are not applied to any uſe, but to afford animal coal in the preparation of the Pruſſian alkali, and in the caſe-hardening of iron.

HOPS. It is univerſally taken for granted, that hops render beer leſs liable to change and become ſour. Neumann affirms the ſame thing, and that it ſenſibly increaſes the ſpirituoſity. It is well known that the aromatic bitter of the hop is an agreeable and probably a wholeſome addition to beer: but the reſt remains yet to be proved by experiment.

HORN. Among the conſiſtent parts of animals, we obſerve a reſemblance in the general properties of ſuch as appear to be diveſted of ſenſation, namely, the bones, horns, hoofs, hair or wool, and ſkin. Some bony ſubſtances are very hard, and appear to conſiſt of much phoſphorated lime, together with about one ſixth of their weight of proper jelly or glue, ſoluble in hot water as well as cold. Ivory, which is ſofter, contains about one fourth of its weight of glue. Hartſhorn, which approaches as much to the nature of bone as horn in its obvious properties, affords about one fifth, and ſkin appears to afford moſt of all. Horn is ſaid to afford no glue*. This ſubſtance differs from bone in its remarkable elaſtic flexibility, and the ſoftneſs it acquires by a moderate heat. It ſeems to be of the ſame nature as hair; and if the fact of its affording no glue were well eſtabliſhed, it would afford ground to think, that its earthy part is combined with a large quantity of ſerous, or fibrous matter, in the coagulated ſtate. See SERUM.

Macquer aſſerts, that horn may be entirely converted into jelly, by treatment with water, in Papin's Digeſter. What happens in this proceſs requires to be examined. Neumann found that twenty-five grains of an extract, of a browniſh colour and ſaline taſte, were obtained by boiling half an ounce of cow's horn in water. When treated in the dry way, horn affords the ſame products nearly as other animal matters, namely, an aqueous alkaline liquor, concrete volatile alkali, and a fetid oil, which, by repeated rectifications, becomes more and more limpid and clear.

Tortoiſeſhell, whalebone, and the hoofs of animals, appear to be nearly of the ſame nature as horn.

HORNBLENDE, or HORNSTONE. This forms the tenth ſpecies of the argillaceous genus of Kirwan's Syſtem of Mineralogy. Its general characters, beſides a partial ſolubility in acids, without effervescencee, and an hardneſs never

* Annales de Chimie, xii. 212; alſo Neumann's Chemiſtry, ii. 336.

ſufficient

ſufficient to ſtrike fire with ſteel, are, 1. a ſpecific gravity, never leſs than 2,66, and in many ſpecimens as high as 3,88; 2. a ſtrong earthy ſmell, when breathed upon, or wetted with hot water; 3. a toughneſs when pounded in a mortar, reſembling that of mica or horn, from which property it obtained its name; 4. its affording a greeniſh grey powder, when pulverized; 5. fuſibility without addition, as it is ſaid; though Mr. Kirwan could not fuſe it with the blow-pipe. It is frequently mixed with pyrites. Of this ſpecies the author reckons three varieties.

Variety 1. Black hornſtone. Corneus nitens Wallerii. Its texture is lamellar, or granular: the former is ſometimes ſo ſoft as to be ſcraped with the nail; its ſurface is frequently as gloſſy as if it had been greaſed: its ſpecific gravity from 3.6 to 3.88, and it poſſeſſes all the ſpecific properties in a high degree. With nitre it does not detonate. When heated it becomes of a ſnuff colour, and then ſlightly effervеſces with diluted nitrous acid: its ſolution in this acid is of a greeniſh colour.

Mr. Kirwan boiled the powder of this ſtone in water, with a view to aſcertain the principle on which its ſmell depends. The water was not altered in taſte, nor did it exhibit any change by the teſts he applied to it. By analyſis he found that 100 grains of the lamellar ſort contained 37 ſilex; 22 clay; 16 magneſia; 2 mild calcareous earth, and 23 calx of iron, not much dephlogiſticated.

Variety 2. Greeniſh grey hornſtone. This is of a granular texture, or ſtriated. The ſpecific gravity of the pureſt ſpecimen Mr. Kirwan could find was 2.683. It is not ſo ſoft as the ſofteſt of the former variety. He ſuſpects the common pale greeniſh grey whetſtone to be of this ſpecies. It is of a cloſe granular texture, exhales an earthy ſmell, affords a greeniſh powder, does not effervеſce with acids, nor give fire with ſteel. Its ſpecific gravity is 2.664. It contains 65 per cent. of ſilex.

Variety 3. Killas. This ſtone is of a pale grey, or greeniſh grey. Its texture either lamellar, or coarſely granular; the lamellar is ſofter and leſs martial than the roof ſlate. Its ſpecific gravity is from 2.63 to 2.666. Mr. Kirwan found 100 grains of the lamellar ſort to contain about 60 ſilex, 25 clay, 9 magneſia, and 6 iron. The greeniſh ſort contains more iron, and gives a greeniſh colour to the nitrous acid.

HOURS, MINERALOGICAL. The direction of veins, with reſpect to the meridian, is in the language of miners denoted by hours. The circle of the horizon is divided into twice twelve hours. The north and ſouth directions are denoted by twelve, and conſequently the eaſt and weſt by ſix o'clock.

HYDROGENE. In the new nomenclature this word denotes the principle to which inflammable air owes its characteriſtic. In the elaſtic ſtate, according to the antiphlogiſtic theory, it is ſuppoſed to be united with the matter of heat, and generally holds water in ſolution or ſuſpenſion. In combination with vital air, it forms water. See AIR INFLAMMABLE.

HYDROMEL. A fermented liquor made of honey and water. It is more commonly known by the name of Mead.

HYDROMETER. The beſt method of weighing equal quantities of corroſive volatile fluids, to determine their ſpecific gravities, appears to conſiſt in incloſing them in a bottle with a conical ſtopper, in the ſide of which ſtopper a fine mark is cut with a file. The fluid being poured into the bottle, it is eaſy to put in the ſtopper, becauſe the redundant fluid eſcapes through the notch, or mark, and may be carefully wiped off. Equal bulks of water, and other fluids, are by

this means weighed to a great degree of accuracy, care being taken to keep the temperature as equal as poſſible, by avoiding any contact of the bottle with the hand, or otherwiſe. The bottle itſelf ſhews with much preciſion, by a riſe or fall of the liquid in the notch of the ſtopper, whether any ſuch change has taken place. See GRAVITY SPECIFIC.

But as the operation of weighing requires conſiderable attention and ſteadineſs, and alſo a good balance, the floating inſtrument called the hydrometer has always been eſteemed by philoſophers, as well as men of buſineſs. It conſiſts of a hollow ball, either of metal or glaſs, capable of floating in any known liquid: from the one ſide of the ball proceeds a ſtem, which terminates in a weight, and from the ſide diametrically oppoſite proceeds another ſtem, moſt commonly of an equal thickneſs throughout. The weight is ſo proportioned, that the inſtrument may float with the laſt mentioned ſtem upright. In the leſs accurate hydrometers this ſtem is graduated, and ſerves to ſhew the denſity of the fluid, by the depth to which it ſinks; as the heavier fluids will buoy up the inſtrument more than ſuch as are lighter. In this way, however, it is clear, that the ſtem muſt be comparatively thick, in order to poſſeſs any extenſive range. For the weight of vitriolic ether is not equal to three-fourths of the ſame bulk of water; and therefore ſuch an hydrometer, intended to exhibit the comparative denſities of theſe fluids, muſt have its ſtem equal in bulk to more than one-fourth of the whole inſtrument. If this bulk be given chiefly in thickneſs, the ſmaller differences of denſity will not be perceptible; and it cannot, with any convenience, be given in length.

To remedy this imperfection, various contrivances have been propoſed, for the moſt part grounded on the conſideration, that a change in the ballaſt or weight employed to ſink the ball, would ſo far change the inſtrument, that the ſame ſhort range of graduations on a ſlender ſtem, which were employed to exhibit the denſities of ardent ſpirit, might be employed in experiments upon water. Some have adjuſted weights to be ſcrewed upon the lower ſtem; and others, with more neatneſs and accuracy, have adjuſted them to be ſlipped upon the extremity of the upper ſtem. But the method of Fahrenheit appears to be on all accounts the ſimpleſt and moſt accurate.

The hydrometer of Fahrenheit conſiſts of an hollow ball, with a counterpoiſe below, and a very ſlender ſtem above, terminating in a ſmall diſh. The middle, or half length of the ſtem, is diſtinguiſhed by a fine line acroſs. In this inſtrument every diviſion of the ſtem is rejected, and it is immerſed in all experiments to the middle of the ſtem, by placing proper weights in the little diſh above. Then as the part immerſed is conſtantly of the ſame magnitude, and the whole weight of the hydrometer is known; this laſt weight added to the weights in the diſh, will be equal to the weight of fluid diſplaced by the inſtrument, as all writers on hydroſtatics prove. And accordingly the ſpecific gravities for the common form of the tables will be had by the proportion:

As the whole weight of the hydrometer and its load, when adjuſted in diſtilled water,
Is to the number 1,000, &c.
So is the whole weight when adjuſted in any other fluid
To the number expreſſing its ſpecific gravity.

In order to ſhew the degree of accuracy an inſtrument of this kind is capable of; it may in the firſt place be obſerved, that the greateſt impediment to its ſenſibility ariſes from the attraction or repulſion between the ſurface of the fluid and that

that of the ſtem. If the inſtrument be carefully wiped with a ſoft clean linen cloth, the metallic ſurface will be equally diſpoſed to attract or repel the fluid. So that if it poſſeſs a tendency to deſcend, there will be a cavity ſurrounding the ſtem; or if, on the contrary, its tendency be to riſe, the fluid will ſtand round the ſtem in a ſmall protuberance. The operator muſt aſſiſt this tendency, by applying the pincers, with which he takes up his weights, to the rim of the diſh. It is very eaſy to know when the ſurface of the fluid is truly flat, by obſerving the reflected image of the window, or any other fit object ſeen near the ſtem in the fluid. In this way the adjuſtment of the weights in the diſh may, without difficulty, be brought to the fiftieth part of a grain. If, therefore, the inſtrument diſplace 1000 grains of water, the reſult will be very true to four places of figures, or even to five. This will be as exact as moſt ſcales are capable of affording.

Some writers have ſpoken of the adjuſtment of an hydrometer of this kind, ſo that it ſhall at ſome certain temperature diſplace 1000 grains of water, as if this were a great difficulty. It is true, indeed, that the performance of a piece of workmanſhip of this nature would require both ſkill and judgment on the part of the artiſt: but it is by no means neceſſary. Nothing more is required on the part of the workman, than that the hydrometer ſhall be light enough to float in ether, and capable of ſuſtaining at leaſt one third of its own weight in the diſh, without overſetting in a denſer fluid. This laſt requiſite is obtained by giving a due length to the ſtem beneath, to which the counterpoiſe is attached. With ſuch an inſtrument, whatever may be its weight, or the quantity of water it diſplaces, the chemiſt may proceed to make his experiments, and deduce his ſpecific gravities by the proportion before laid down. Or to ſave occaſional computation, he may once for all make a table of the ſpecific gravities, correſponding to every number of the load in the diſh, from one grain up to the whole number of grains, ſo that by looking for the load in one column, he may always find the ſpecific gravity in the column oppoſite. I find this method very ready and convenient in practice: but, if it be preferred, the weights may be adjuſted to the hydrometer, ſo as to ſhew the ſpecific gravity, without computation or reference. For this purpoſe the hydrometer muſt be properly counterpoiſed in diſtilled water, at the aſſumed ſtandard temperature; ſuppoſe 60°, and the whole weight of the inſtrument and its load called 1.000, &c. Then the weight of the inſtrument and its load muſt be ſeparately determined in grains and parts, or other weights, by a good pair of ſcales. And as the whole weight of the inſtrument and its load is proportioned to the weight of the inſtrument alone; ſo will be the number 1.000, &c. to a fourth term expreſſing the weight of the inſtrument in ſuch parts as make the whole 1.000, &c. Make an actual ſet of decimal weights (ſee BALANCE, page 191, § 16, 17), of which 1.000, &c. ſhall be equal to the hydrometer and its load. And it is clear, that whatever may be the load in theſe weights, if it be added to the number denoting the weight of the inſtrument, the ſum will denote the ſpecific gravity of the fluid, wherein the inſtrument floats with that load.

By following the above eaſy method it will be found, that every hydrometer, whereſoever made, muſt give the ſame reſults. The ſubject is indeed in itſelf ſufficiently ſimple, and would require ſcarcely any diſcuſſion, if it had not happened that many philoſophers, for want of requiſite attention, have made their experiments with hydrometers graduated on the ſtem, by no certain rule by which operators at a diſtance from each other might compare their experiments. The

hydrometers, or *peſe-liqueurs* of Baumé, though in reality comparable with each other, are ſubject in part to the defect, that their reſults, having no independent numerical meaſure, require explanation to thoſe who do not know the inſtruments. Thus, for example, when a chemiſt acquaints us that a fluid indicated 14 degrees of the *peſe-liqueur* of Baumé, we cannot uſefully apply this reſult, unleſs we have ſome rule to deduce the correſpondent ſpecific gravity: whereas we ſhould not have been in any reſpect at a loſs, if the author had mentioned the ſpecific gravity itſelf. As a conſiderable number of French philoſophers refer to this inſtrument, it will be of uſe to explain its principles.

M. Baumé * appears to have directed his attention chiefly to the acquiſition of a means of making hydrometers with a graduated ſtem, which ſhould correſpond in their reſults, notwithſtanding any differences in their balls or ſtems. There is little doubt but he was led into the method he adopted, by reflecting on that by which thermometers are uſually graduated (ſee THERMOMETER). As thermometers are graduated, independent of each other, by commencing with an interval between two ſtationary points of temperature, ſo M. Baumé adopted two determinate denſities for the ſake of marking an interval on the ſtem of his hydrometer. Theſe denſities were thoſe of pure water, and of water containing $\frac{15}{85}$ parts of its weight of pure dry common ſalt in ſolution. The temperature was 10 degrees of Reaumur above freezing, or 57° of Fahrenheit. His inſtrument for ſalts was ſo balanced, as nearly to ſink in pure water. When it was plunged in this ſaline ſolution, the ſtem aroſe in part above the ſurface. The elevated portion was aſſumed to be 15 degrees, and he divided the reſt of the ſtem with a pair of compaſſes into ſimilar degrees.

It is unneceſſary to enquire in this place, whether this interval be conſtant, or how far it may be varied by any difference in the purity, and more eſpecially the degree of dryneſs, of the ſalt. Neither will it be requiſite to enquire how far the principle of meaſuring ſpecific gravities by degrees repreſenting equal increments, or decrements, in the bulks of fluids, of equal weight but different ſpecific gravities, may be of value, or the contrary. It does not ſeem probable that Baumé's inſtrument will ever become of general uſe; for which reaſon nothing farther need be aſcertained, than the ſpecific gravities correſponding with its degrees, in order that ſuch experiments as have this element among their data, may be eaſily underſtood by chemical readers.

M. Baumé's hydrometer for ſpirits was conſtructed from an interval of ten degrees experimentally found as above, by diſſolving ten parts by weight of common ſalt, in ninety of water. I find by experiment, that this ſolution affords a diviſion which does not differ from that before obtained from the ſolution of fifteen parts of ſalt in eighty-five of water. I find alſo, that the ſpecific gravity of this laſt-mentioned ſolution, at the temperature of 57° Fahrenheit, is 1.105. Whence I have computed the following table:

* Eléments de Pharmacie: cinquieme édition, Paris 1784, page 396.

TABLE

TABLE of Specific Gravities, correſponding with the Degrees of the Hydrometers, or Peſe-Liqueurs of Baumé.

Hydrometer for Salts — for ardent Spirit.

Deg.	Sp. Gr.	Diff.
45	0.778	
		20
40	0.798	
		21
35	0.819	
		22
30	0.841	
		22
25	0.863	
		25
20	0.888	
		25
15	0.913	
		28
10	0.941	
		28
5	0.969	
		31
0	1.000	
		33
5	1.033	
		34
10	1.067	
		38
15	1.105	

Hydrometer for Salts.

Deg.	Sp. Gr.	Diff.
20	1.145	
		43
25	1.188	
		46
30	1.234	
		51
35	1.285	
		54
40	1.339	
		59
45	1.398	
		64
50	1.462	
		71
55	1.533	
		78
60	1.611	
		87
65	1.698	
		96
70	1.794	
		108
75	1.902	
		122
80	2.024	

It muſt be remarked, with regard to this table, that the degrees of the hydrometer at which Baumé found his pureſt ardent ſpirit, correſpond with a ſpecific gravity ſo much higher than that of any ſpirit I have ever heard of, that I am diſpoſed to ſuſpect an inaccuracy in the principle on which the inſtrument is to be conſtructed.

There are a variety of hydrometers uſed for determining the ſtrength of ardent ſpirits. See SPIRIT ARDENT.

HYDROPHANES. This ſtone, which is alſo called oculus mundi, and lapis mutabilis, was formerly of great value. Its diſtinguiſhing characteriſtic is that of becoming tranſparent by immerſion in water. Bergman has written a diſtinct treatiſe upon it.

The hydrophanes is either of a whitiſh brown, yellowiſh green, milky grey, or yellow colour, and opake. Some ſpecimens give fire with ſteel. Its ſpecific gravity is about 2.048, and it is eaſily cut and poliſhed. Without addition, it is infuſible; but the flame of the blow-pipe changes it into a brown brittle ſubſtance. Neither acids nor alkalis have any action upon it in the humid way.

Three of theſe ſtones are to be ſeen in the Britiſh Muſeum in London. The largeſt is about the ſize of a cherry ſtone, but of an oval form. It is opake, and in colour reſembling the common yellow pea. It may be ſcratched, though not without difficulty, with a knife, but it ſeems to leave a trace upon common glaſs. The acid of nitre does not cauſe any ebullition when applied to it.

When it has lain in water ſome hours it becomes tranſparent, and of a yellow amber colour. This change begins ſoon after the immerſion, and at one end, in the form of a ſmall ſpot (but in a ſmall one of the ſame kind the beginning is round the edges), which increaſes by ſlow degrees, till the whole ſtone has become uniformly clear throughout. When taken out of the water, it loſes its tranſparency, firſt at one end, and then gradually over the remainder. This change happens in leſs time than is required to produce the tranſparency, as might

might indeed be naturally expected. For the ſtone cannot become tranſparent, until the water has ſoaked through its whole ſubſtance; but it becomes opake, as ſoon as a certain thickneſs from the ſurface is well dried.

There is no doubt but this phenomenon is produced in the ſame way as oil or water renders paper tranſparent. It depends on a general principle, which is well explained by Sir Iſaac Newton, in his Optics, viz. that all porous bodies may be rendered tranſparent, by filling their pores with ſome other matter of nearly the ſame denſity. For in this laſt caſe the light paſſes through with very little impediment, or deviation; whereas it was before ſubject to reflection and refraction at all the ſurfaces of the groſſer particles, and therefore became abſorbed and loſt. That the hydrophanes abſorbs moiſture, and emits air, which is a fluid of much leſs denſity, is evident from the weight it acquires, and the ſmall bubbles which cover its ſurface during the time it acquires tranſparency.

Theſe facts evidently ſhew that the effect ariſes from a coarſe poroſity in the ſtructure of this ſtone. It is a general circumſtance, that thoſe ſiliceous ſtones which reſemble the common flint in breaking ſmoothly and equally, are frequently ſurrounded by a covering of coarſer material. Bergman thinks theſe coarſer parts were extruded by the contraction of the more homogeneous matter, during the gradual tranſition from the ſoft to the hard ſtate. It is not eaſy to form any notion of a mechanical action of this kind; and it ſeems more probable that the coarſeneſs, or rather poroſity, of theſe external cruſts may have ariſen from the action of water, air, or other agents, which during a long courſe of time may have carried off ſome of the parts to a certain depth, or have cracked, ſplit, or deſtroyed the continuity to a certain depth, as is ſeen upon the ſurface of broken flints, and other ſtones expoſed to the weather. Theſe cruſts muſt neceſſarily differ in texture, denſity, and hardneſs; and accordingly it cannot be expected, that the requiſites of the hydrophanes ſhould be very frequently met with. The proper pieces, which are generally ſurrounded with ſuch as are uſeleſs, cannot be diſtinguiſhed by their external appearance; but ſuch as do not adhere to the tongue may be rejected. Immerſion in water for a day will determine their quality, becauſe ſuch as require a longer time to become tranſparent are of no value.

Though it is probable that the cruſts of all the varieties of ſiliceous ſtones may yield the hydrophanous ſtone, yet experience ſhews that it is chiefly to be ſought for among thoſe of a looſe texture, ſuch as opals and chalcedonics. The opal gives admittance to water, but wants the opacity requiſite to make the experiment ſtriking. If it be rendered opake by fire, which muſt be very cautiouſly and gradually applied, it becomes the hydrophanes. Too ſudden heat cauſes it to fly in pieces.

Bergman found the ſame component parts in the opal and the hydrophanes. He reduced the ſtone to a very fine powder, and ſeparated 100 grains of the moſt ſubtile particles by elutriation. He formed this into a ball, with three times as much mineral alkali, and a little water, and expoſed it for an hour and half in an iron veſſel to a fire gradually raiſed, but not to ſuch a degree as to melt the maſs. If this laſt event ſhould happen, which it is difficult to prevent, the fluid becomes loaded with iron, and is ſo troubleſome to analyſe, that it is better to repeat the proceſs as at firſt, but with more care. After a certain time the ball ſplits again into a powder, by the diſſipation of part of the alkali. In this powder the ſiliceous earth was combined with alkali, and the other earths were rendered much more acceſſible to acid menſtruums, from which the ſilex might have

have defended them. By digeſtion of the powder in marine acid, he found that ſixteen parts of argillaceous earth were taken up, and eighty-four parts of ſiliceous earth remained untouched. There was not the ſmalleſt appearance of any thing calcareous.

The value of the hydrophanes is eſtimated by its bulk, the quickneſs of the change, and the beauty of its colour. Of two equally penetrable, the larger muſt be longer in becoming tranſparent; but the effect may be increaſed by giving them a flat thin figure. The colour is derived from iron. Hot water produces the effect more ſpeedily than cold. If frequent repetition of the experiment ſhould render the ſtone leſs diſpoſed to become tranſparent on immerſion, it will moſt probably have ariſen from calcareous depoſition; in which caſe it may be cleared by immerſion in acids. Alkalis, or acids, penetrate this ſtone, and render it tranſparent; the concentrated vitriolic acid renders it permanently ſo, by attracting water from the atmoſphere. But the opacity may be reſtored by immerſing it in an hot alkaline liquor. Nitrous acid highly concentrated calcines the iron, and alters the colour of this ſtone, by that means producing various ſhades of yellow. Bergman thinks that acids, by diſſolving part of the argillaceous earth, may improve the quality of ſuch ſtones as admit the water too ſlowly.

This ſtone probably received the name of oculus mundi, from an internal ſpark, or luminous ſpot, which changes its poſition according to the direction of the incident light. Bergman has made the moſt accurate remarks on this phenomenon, and finds that it proceeds from the cauſtic curves, and focal image, by refraction from the uſual rounded form of the ſtone, and rendered viſible by the ſemi-opacity of the material through which the light paſſes.

Though this mutability is chiefly found in ſtones of the ſiliceous order, yet as it depends upon the mechaniſm or conſtruction, rather than the component parts, it may naturally be expected to be met with in the other orders. The requiſites are, that tranſparent particles ſhould be ſo joined, or agglutinated together, as to leave innumerable minute interſtices capable of admitting water. This conſtruction is ſometimes met with among the ſteatites. It may eaſily be underſtood how this may be rendered tranſparent, as more than half its weight conſiſts of ſiliceous particles, frequently pellucid. But the hydrophanous ſteatites, being loaded with magneſia, ſeldom acquires the ſame degree of tranſparency as thoſe which almoſt entirely conſiſt of ſiliceous earth, which are likewiſe harder, though leſs beautiful and various in their colours. Dr. Bruckman, quoted by Bergman, mentions red, white, green, and grey ſteatites poſſeſſed of this property. He directs that they ſhould be firſt boiled in an alkaline lixivium, and then in vinegar.

I

ICE ICE

ICE. Water in the ſolid ſtate. Mairan obſerved that water, in freezing, has a tendency to form angles of ſixty degrees, and to form ſtars with ſix rays. Romé de Liſle calculates, that the primitive form of ice is an equilateral eight-ſided figure. Haſſenfratz has obſerved, that water, when it freezes under favourable circumſtances, always aſſumes an hexahedral priſmatic form. This fact is not inconſiſtent with the deduction of R. de Liſle.

The ſpecific gravity of ice being conſiderably leſs than water, it always floats at the ſurface, where it is moſt commonly formed in conſequence of the ſuperior coldneſs of the atmoſphere. It may nevertheleſs be formed at the bottom or ſide of any veſſel, if the temperature be more effectually diminiſhed in thoſe parts than elſewhere, as by a freezing mixture. Ice is ſometimes formed at the bottom of running waters, which Hales explains by remarking, that the ſuperior parts of ſtagnant waters, as alſo of the earth, are colder in froſty weather than the inferior; but in running waters the uppermoſt parts are mixed with the lower, and all are cooled nearly alike; and as the water at the ſurface flows quicker than that below, the water at the bottom freezes ſooneſt. There ſeems to be ſomething defective in this explanation; for, as far as we know, agitation can impede freezing or cryſtallization in no other way than by mixing the warmer parts of the fluid with the colder. But there is no doubt of the fact, from the concurring teſtimony of fiſhermen and other inhabitants near rivers, who are well acquainted with ground ice; beſides which, M. Pott made an experiment in froſty weather with two ſimilar tubs, into each of which were thrown nails, iron wire covered with flannel, hair, &c. A current of water was made to paſs through one of them, and in the other was placed water with no current. Ice was formed on the nails and other ſubſtances at the bottom of the former, but none at the ſurface. And in the latter the ſurface was congealed, but there was no ice at the bottom. I am inclined to think that the formation of ground ice depends on the ſprings, which iſſue from the earth at a more elevated temperature than the freezing point; namely, at the medium temperature of the climate. Suppoſe a ſpring to iſſue from the earth at the temperature of 40°, into a freezing atmoſphere, it naturally follows, and experience ſhews, that the ſtream muſt run over a certain extent of ground before it can be cooled as low as 32°, and become congealed. And if other ſprings flow into it from diſtances nearer their own ſources, the diſtance of the place of congelation from the firſt ſource may be ſtill more augmented. When the original ſtream has increaſed to the ſize of a river, the effect of the additional ſprings will be confined to the ſurface. Hales is miſtaken in ſuppoſing that the water at the ſurface flows quickeſt, for all hydroſtatical writers prove the contrary. Suppoſe now that the water be cooled as low as 32°, or lower, at a certain part of the river. It will there begin to freeze, and the larger maſſes will be accumulated where the cryſtallization is leaſt diſturbed, namely, at the edges. But the ſubſequent acceſſary ſtreams will flow on the ſurface of this, becauſe warmer, and conſequently lighter; and as the lower part of a river runs the ſwifteſt, it will follow

follow that the ſtream, in the act of congelation, will flow on beneath the upper and warmer ſtream, and depoſit ice upon the ſtones at the bottom, while none appears at the ſurface. If this explanation be true, it will be found, 1. That wherever ground ice is found, there will be ice at the ſurface, higher up the ſtream; and, 2. the river has received a ſupply from ſome warmer ſprings at ſome place intermediate between the places where the ice is formed at the ſurface, and where it is formed at the bottom.

The expanſive force of water, when it is converted into ice, is greater than any ſtrength in the texture of bodies which has been oppoſed to it. Boyle and Hales made the experiment with piſtol-barrels and bomb-ſhells, which were burſten by the expanſion. Other philoſophers have ſince repeated theſe experiments with ſimilar reſults.

The freezing point of water is the 32° on Fahrenheit's ſcale. See HEAT, THERMOMETER, WATER.

ICELAND SPAR. A ſubſtance which has greatly engaged the attention of philoſophers, under this name, or the name of Iceland cryſtal. Bartholin, Huyghens, Newton, Beccaria, and others of later date, have made experiments on its remarkable property of ſeparating the rays of light in ſuch a manner as to exhibit two images of an object ſeen through it. It is the tranſparent ſpecimen of common calcareous ſpar, and uſually contains about 54 parts lime, 35 fixed air, and the reſt water. Its ſpecific gravity is about 2,7. Prieſtley's Optics, and the authors referred to by him, may be conſulted, for an account of as much of the laws of this unuſual refraction as is yet known. Magellan * ſays, that M. Fromond, profeſſor of natural philoſophy at Milan, has obſerved that glaſs has the ſame effect, whenever a number of parallel lines have been cut on its ſurface with a diamond, at the diſtance of the five hundredth or thouſandth of an inch aſunder; and that he (M.) had ſeen one of the pieces of glaſs which produced this effect. Hence it ſhould ſeem as if the effect were produced either by inequalities at the ſurface, or fiſſures in the maſs itſelf.

ICHTHYOCOLLA. Fiſh-glue, or *Iſinglaſs*; which ſee.

IGNIS FATUUS. A luminous appearance or flame, frequently ſeen in the night in different country places, and called in England *Will-with-the-wiſp*. It ſometimes appears in the form of a flame dancing or undulating above the lower plants of the field; in other inſtances it has the appearance of an extenſive luminous exhalation; ſometimes it is ſeen to have a conſiderably rapid progreſſive motion; and other obſervations ſhew that it may have a ſtationary appearance, and definite form. Philoſophers are not agreed as to its cauſe; but it appears probable that theſe meteors near the ſurface of the earth may not all be of the ſame nature. It ſeems with us to be moſtly occaſioned by the extrication of phoſphorus from rotting leaves and other vegetable matters, which may be carried up in the firſt ſtate of combuſtion by the ſummer heat, and rendered viſible at night. Whether the inflammable air extricated from marſhes may produce an appearance of this kind, is doubtful. It is probable that the motionleſs ignes fatui of Italy may be produced by the ſlow combuſtion of ſulphur, emitted through clefts and apertures in the ſoil of that volcanic country.

ILLUMINATION. See LIGHT.

INCINERATION. The combuſtion of vegetable or animal ſubſtances, for the purpoſe of obtaining their aſhes or fixed reſidue.

* On Cronſtedt, i. 26.

INCOMBUSTIBLE CLOTH. See ASBESTOS.

INCRUSTATION. When the external part of any mineral is of a different texture and appearance from the internal part, the former is called the incruſtation.

INDIGO. A blue colouring matter extracted from a plant called Anil, or the Indigo Plant. See ANIL.

In the preparation of this drug the herb is put into a vat or ciſtern, called the ſteeping trough, and there covered with water. The matter begins to ferment ſooner or later, according to the warmth of the weather and the maturity of the plant; ſometimes in ſix or eight hours, and ſometimes in not leſs than twenty. The liquor grows hot, throws up a plentiful froth, thickens by degrees, and acquires a blue colour inclining to violet. At this time, without touching the herb, the liquor impregnated with its tincture is let out by cocks in the bottom into another vat placed for that purpoſe, ſo as to be commanded by the firſt. M. Quatremere ſays, that inflammable air is diſengaged during this fermentation.

In the ſecond vat, called the beating vat, the liquor is ſtrongly and inceſſantly beaten with a kind of buckets faſtened to poles, till the colouring matter is united into a body. Lewis*, from Labat, ſays, that much nicety is required to hit the point at which the colour is diſpoſed to ſubſide, becauſe it is again taken up if the beating be too long continued; and that the manufacturers accordingly make frequent obſervations on ſmall quantities of the liquid taken out in a cup. But this does not agree with the aſſertion of M. Le Blond †, who affirms that the effect of beating is to diſſipate a quantity of fixed air, by which the blue fecula is ſuſpended; that this method is inſufficient to throw down the whole; but that the addition of lime water completely accompliſhes it. It is ſaid by Labat, that lime-water, or lime, is ſometimes uſed in the beating; and he conjectures, that the hardneſs or flintineſs of ſome indigo may be cauſed by this practice.

As ſoon as it is judged from the blue colour of the liquid that the beating is ſufficient, it is left at reſt for two hours; after which the clear liquor is drawn off by cocks in the ſide of the vat, and the blue part is diſcharged by another cock into a third vat, where it is ſuffered to ſettle for ſome time longer; then conveyed in a half fluid ſtate into bags of cloth, to ſtrain off more of its moiſture; and laſtly, expoſed to the air in the ſhade in ſhallow wooden boxes, till it is thoroughly dry.

The indigo thus produced differs in its quality, not only according to that of the plant, but likewiſe the care taken in manufacturing it. Its colouring part appears nevertheleſs to be always the ſame, and its variations depend only on the admixture of foreign matter, and the conſiſtence it acquires in drying.

Berthollet ſpeaks of the indigo from Guatimala, as the beſt of any. It is ſo light as to ſwim on the ſurface of water inſtead of ſinking to the bottom, as all the other kinds do. Another kind is called coppery indigo, becauſe its ſurface acquires a copper colour when rubbed with a hard body: there are other kinds of leſs purity, ſuch as that from Carolina.

Bergman examined this drug in his uſual maſterly way: he found that one ninth part of the indigo was taken up by boiling it in water. The parts diſſolved were partly mucilaginous, partly aſtringent, and partly ſaponaceous. The

* On Neumann, ii. 237. † Berthollet on Dying, ii. 47. But vide infrà, p. 398.

ſolution

ſolution of alum, and of martial as well as cupreous vitriol, precipitate the aſtringent portion.

M. Quatremere likewiſe ſeparated the ſoluble part of indigo by means of water. He pretends that the quantity thus taken up is more in proportion, as the indigo is of inferior quality; and affirms, that the indigo thus purified is equal to the beſt. Berthollet remarks upon this method of purifying, that though doubtleſs advantageous, it is not perfectly effectual, becauſe it leaves the earthy inſoluble parts, which, though not detrimental to the colour, muſt certainly affect the proportion of colouring matter.

Powder of indigo, digeſted in pure ardent ſpirit, afforded a tincture, firſt yellow, then red, and laſtly brown. By ſeveral repetitions of this proceſs it loſt one twenty-ſeventh part of its weight. Water being added to the ſpirit, threw down a browniſh reſinous matter.

Ether had nearly the ſame action on indigo as the ardent ſpirit; but oils, whether fixed or volatile, affected it very little.

Bergman mixed one part of well pulverized indigo with eight parts of colourleſs vitriolic acid, of the ſpecific gravity of 1,900, in a glaſs veſſel ſlightly cloſed. The acid very quickly acted upon the indigo, and excited much heat. After a digeſtion of twenty-four hours the ſolution was effected; but the mixture was opake and black. By the addition of water it became more tranſparent, exhibiting in ſucceſſion all the ſhades of blue, according to the quantity of water added. At leaſt twenty pounds of water were required to render the ſmalleſt drop of the ſolution imperceptible in a cylindric glaſs of ſeven inches diameter.

If the vitriolic acid be firſt diluted in the water, it attacks only the earthy principle which is mixed with the indigo, and ſome of the mucilaginous parts.

The fixed alkalis perfectly mild, that is, ſaturated with fixed air or aerial acid, ſeparate a very fine blue powder from the ſolution of indigo, which is depoſited very ſlowly. Bergman diſtinguiſhes this by the name of precipitated indigo. It is alſo obtained by pouring the ſolution drop by drop into ardent ſpirits, or into the ſaturate ſolutions of alum, of Glauber's ſalt, or of other ſalts containing the vitriolic acid. But the liquid always remains a little coloured.

The concentrated nitrous acid attacks indigo with ſo much activity as to ſet it on fire; but if the acid be properly diluted, it acts with leſs violence. The colour of the indigo becomes ferruginous, and the reſidue, which has the appearance of amber, amounts to no more than one third of the weight of the indigo. Fixed alkali precipitates from the acid a ſmall quantity of calx of iron, mixed with the calcareous and ponderous earths. But if too much alkali be added, part of the precipitate is re-diſſolved, and the colour of the fluid is rendered deeper than before.

Hauſſman, in a very intereſting diſſertation *, has given a more connected ſet of obſervations on the changes produced in indigo by the pale nitrous acid. When the whole of the indigo he had expoſed to the action of this acid had appeared to be deſtroyed, he found in the veſſel a coagulum, which, after all the nitrous acid had been carried off by waſhing, formed a brown viſcid maſs of the appearance of a gum reſin. It was ſoluble in pure ardent ſpirit, which indigo is not, and was not ſoluble in water, but when the quantity was great. It was more ſoluble in hot water than cold, and was conſiderably bitter. The water which had been uſed in the lotions, afforded by evaporation ſmall cryſtals, which

* Quoted by Berthollet on Dying, ii. 34. It is found in the J. de Phyſique for March 1788.

exhibited ſeveral of the properties of the acids of tartar and of ſorrel, but which were not preciſely determined by the author.

The marine acid by digeſtion, and even boiling upon indigo, takes up the earthy matter, the iron, and a little of the extractive matter, which gives it a brown colour, but in no reſpect attacks the blue colour. If the indigo be precipitated from the vitriolic acid, the marine acid will very readily take up a certain quantity, and acquires a deep blue colour.

Other acids, ſuch as thoſe of tartar, of ants, of vinegar, and of phoſphorus, have the ſame habitudes with indigo as the marine; that is, they do not attack it, but diſſolve the precipitate very well. Vitriolic acid too much diluted to be capable of diſſolving indigo, or nitrous acid, which from the ſame cauſe is too weak to act upon it, take up only the earthy and extractive parts, which are foreign to the colouring matter.

The dephlogiſticated or aerated marine acid has ſcarcely any effect upon indigo in ſubſtance; but it deſtroys the colour of indigo in a ſtate of ſolution. Berthollet applied it to the ſolution in vitriolic acid. By the admixture of the aerated marine acid the blue colour was entirely deſtroyed, and the fluid became of a yellow brown. He evaporated it in this ſtate, and obtained by gradual depoſition a viſcid blackiſh matter, which appeared to be of the ſame nature as that afforded to Mr. Hauſſman by the nitrous acid.

This effect of the aerated marine acid is conſidered by Berthollet, as affording a good method of aſcertaining the proportional quantities of colouring matter in the different kinds of indigo. For this purpoſe he takes equal weights of each carefully powdered, and puts them into ſeparate mattraſſes, with eight times their weight of concentrated vitriolic acid. Theſe are to be kept for twenty-four hours in a heat between 100° and 120° of Fahrenheit, for which purpoſe a dunghill, or the tan bed of an hot-houſe, may be employed. Each ſolution is then diluted with an equal quantity of water filtered, and the reſidue found on the filters collected, ſeparately ground in a glaſs mortar, again digeſted with a little vitriolic acid, diluted with equal quantities of water, and each added to its correſponding liquor. And laſtly, to each ſolution is added ſo much aerated marine acid as is neceſſary to diſcharge the colour, or rather to bring them all to the ſame ſhade of yellow. The goodneſs of each kind of indigo is proportionate to the quantity of aerated acid employed to deſtroy the colour.

Pure or cauſtic fixed alkali diſſolves ſome matters foreign to the colouring matter of the indigo, but acts very little on the colouring particles. Pure volatile alkali has nearly the ſame effect. Precipitated indigo is ſpeedily diſſolved in the cold in the alkalis, whether fixed or volatile, if pure or cauſtic. The blue colour is gradually changed to a green, and at laſt deſtroyed. But mild alkalis do not alter the colour. Lime water has little action upon indigo; but it diſſolves it when precipitated, and affects the colour nearly in the ſame manner as cauſtic alkalis do.

Indigo expoſed to the action of fire in an open crucible, or under a muffle, ſmokes, ſwells up, ignites, and ſometimes takes fire with a white flame. One hundred parts of indigo leave thirty-three or thirty-four parts of aſhes. Theſe do not afford fixed alkali when lixiviated with diſtilled water. Marine acid diſſolves the greateſt part of the aſhes with a ſlight effervescence. The inſoluble remainder is about one eleventh part, and has the characters of ſiliceous earth.

From

From this muriated ſolution the Pruſſian alkali throws down from thirty to thirty-two grains of the blue precipitate, which repreſents five or ſix of iron in the ounce. The aſhes likewiſe contain the calcareous and ponderous earths, beſides the iron and ſilex.

Indigo detonates ſtrongly with nitre. By deſtructive diſtillation it affords fixed air, a liquor containing a little volatile alkali, and an oil reſembling the empyreumatic oil of tobacco, and very ſoluble in ardent ſpirit.

Bergman concludes from his analyſis, that one hundred parts of good indigo contain

Of mucilaginous matter ſeparable by water -	12
Reſinous matter ſoluble in ardent ſpirit -	6
Earthy matter taken up by the acetous acid, which does not attack the iron here in the ſtate of calx	22
Calx of iron taken up by the marine acid -	13

There remained forty-ſeven parts, which are the colouring matter, nearly in a ſtate of purity; and afforded by diſtillation,

Fixable air - - -	2
Alkaline liquor - - -	8
Empyreumatic oil - - -	9
Coal - - - -	23

The coal when burned in the open air afforded four parts of earth, of which nearly half was calx of iron, and the reſt ſiliceous earth in a very ſubtle powder.

From theſe reſults Bergman concludes, that indigo is a ſubſtance analogous to Pruſſian blue and the colouring matter of ink; and that its colour, like thoſe, is owing to iron. Upon this deduction Berthollet * remarks, with regard to Bergman's inference reſpecting the iron, that by an error in eſtimating the value of the Pruſſian blue, this great chemiſt has ſtated the quantity of this metal about four times too large; that the iron taken up by marine acid is extraneous to the pure indigo, as well as the earths, and the mucilage and reſin taken up by water and ardent ſpirit. So that, on an accurate conſideration of the facts, there does not appear to be more than one thirtieth part of iron in a combined ſtate. He obſerves, that it is at preſent well known, that the products of deſtructive diſtillation, ſuch as oil, carbonic acid, or fixed air, and volatile alkali, do not previouſly exiſt in bodies, but are afforded by new combinations of the principles which formed the body acted upon. And accordingly he concludes, that indigo contains a conſiderable quantity of hydrogene or inflammable air in a fixed ſtate, a ſmall quantity of azote or phlogiſticated air, a very ſmall portion of iron, and particularly a larger quantity of coal than is obtained from any other known vegetable ſubſtance. It does not appear whether the ſiliceous earth be merely an admixture, or whether it enter into the combination of the colouring matter.

From the great quantity of coal and inflammable air, he accounts for the combuſtibility of this ſubſtance, its detonation with nitre, and the effects of the nitrous and marine acids upon it. The fixity of its colour is alſo, in conformity to other obſervations of Berthollet, deduced from the quantity of coal, which is but ſlowly conſumed by the action of vital air from the atmoſphere. From a mature conſideration of the proceſs of the manufactory, this intelligent author

* Art of Dying, ii. 56.

deduces,

deduces, that the indigo exiſts in the plant in a reſinous ſtate; that the kind of putrefaction it undergoes is of the nature of combuſtion, during which, part of its inflammable air is burned, and part flies off; and that the utility of the proceſs of beating, is grounded on the facility it affords for the abſorption of vital air. If the beating be continued too long, the indigo is rendered black, and becomes what is called burnt indigo.

The ſolubility of indigo in alkalis appears to be produced by the abſtraction of part of the vital air it had abſorbed, or, according to the ancient theory, by virtue of a proceſs of phlogiſtication. This appears to be well eſtabliſhed from the experiment of Bergman, wherein equal weights of martial vitriol and indigo, and double the weight of lime, are mixed together in water, and produce a ſolution of the indigo in the lime-water. But if the iron of the vitriol be previouſly calcined to a higher degree, by boiling it in much water for ſeveral hours, and ſubſequent evaporation, the ſolution will not be effected, becauſe the precipitated iron is no longer diſpoſed to abſorb vital air, as the experiments of Prieſtley ſhew the common precipitate from vitriol to be. Or again, if indigo be added to a ſolution of cauſtic fixed alkali, and orpiment be added (which conſiſts of arſenic and ſulphur), the indigo is ſoon diſſolved, and takes a green colour. If the arſenic correſponding with the orpiment be only added, the bath will never be fit for the dyer; but if the quantity of ſulphur it ought to contain be added, the appearances of ſolution will ſpeedily be had.

Mr. Hauſſman proved by a direct experiment, that the ſolution of orpiment mixed with indigo is diſpoſed to abſorb vital air. For having placed this ſolution, which is known in the dye-houſes by the name of printing blue, in contact with vital air expelled from nitre, ſeven-eighths of the air was abſorbed, and the remainder was phlogiſticated air. The blue ſolution was entirely ſpoiled. The indigo was regenerated. Some of the alkali formed vitriolated tartar with the acid; a portion of the alkali remained pure and uncombined; and the arſenic, inſtead of being in the metallic ſtate as it is in the orpiment, was combined with it in the form of calx, or probably acidified.

It follows therefore, that indigo contains vital air in its natural ſtate; that in this ſtate it will not unite with lime or alkalis; but that ſubſtances capable of depriving it of part of its vital air, render it ſoluble in lime or alkalis; and laſtly, that the natural ſtate of the indigo is reſtored by the contact of vital air which it abſorbs. In this laſt way it is that the blue dye is effected. The piece comes out of the vat of the ſame colour as the ſolution: viz. green; but becomes blue by expoſure to the air. The alkali, or lime, is carried off by the waſhing, and the indigo remains combined with the ſtuff by this means dyed.

The action of acids, even the vitriolic, upon indigo, appears to affect it in the way of combuſtion; by which it is ſo far altered as not to adhere ſo ſtrongly to wool or ſilk as when in its natural ſtate. For other intereſting particulars, conſult the Memoir of M. Hauſſman before cited, and compare with the Theories of Bergman and Berthollet.

INFERNAL STONE. Lapis infernalis. A name frequently given to the combination of ſilver with the nitrous acid, which is fuſed into little ſticks to be uſed as a cauſtic.

INFLAMMABLE AIR. See AIR INFLAMMABLE.

INFLAMMABLE PRINCIPLE. See PHLOGISTICS.

INFLAMMATION of OILS. See ACID NITROUS.

INFUSION. The word infuſion is uſed by chemiſts, to denote a quantity of water loaded with as much of the principles of any ſubſtance, not totally ſoluble, as it will take up in the uſual temperature of the atmoſphere.

INK. Every liquid or pigment uſed for writing or printing, is diſtinguiſhed by the name of ink. Common practice knows only black and red.

Of black ink there are three principal kinds: 1. Indian ink, 2. printers' ink, and 3. writing ink.

The Indian ink is uſed in China for writing with a bruſh, and for painting upon the ſoft flexible paper of Chineſe manufacture. It is aſcertained as well from experiment as from information, that the cakes of this ink are made of lamp black and ſize, or animal glue, with the addition of perfumes or other ſubſtances not eſſential to its quality as an ink. It is uſed in Europe for deſigns in black and white, in which it poſſeſſes the advantage of affording various depths of ſhade, according to its ſtate of dilution with water.

The general compoſition of printers' ink is well known, but the particulars of the proceſs by which ink of the beſt quality is made are kept ſecret by the few manufacturers of this article. It is probable, that the demand is not ſufficient to afford inducements for men of reſearch to make many experiments on this object, and it is not unlikely that much may depend on minute circumſtances in the management.

Good printers' ink is a black paint, ſmooth and uniform in its compoſition, of a firm black colour, and poſſeſſes a remarkable aptitude to adhere to paper thoroughly impregnated with moiſture. It is remarkable, that this compoſition adheres uniformly to the wetted ſheep-ſkin cover of the printers'-balls, which a common oil paint would not do; that it quits the wet ball to adhere to the face of the dry metallic type, and this ſo perfectly as to leave a new ſkin bare where the type touches it; and that much the greater part of the ink afterwards leaves the type to adhere to the moiſtened paper, but will not if the paper be dry. If the ink do not poſſeſs theſe requiſites, it will not work well, but will clog the face of the letter, and give an imperfect impreſſion.

The * conſiſtence and tenacity of the oil in this compoſition are greatly increaſed, and its greaſineſs diminiſhed, by means of fire. Linſeed oil or nut oil is made choice of for this uſe. The nut oil is ſuppoſed to be the beſt, and is accordingly preferred for the black ink, though the darker colour it acquires from the fire renders it leſs fit for the red. It is ſaid, that the other expreſſed oils cannot be ſufficiently freed from their unctuous quality; whence the ink made with them dries exceeding ſlowly, is apt to come off and ſmear the paper in the beating and preſſing it undergoes in the hands of the bookbinder, or ſinks into the ſubſtance of the paper beyond the mark of the type, and ſtains it yellow.

Ten or twelve gallons of the oil are ſet over the fire in an iron pot, capable of holding at leaſt half as much more; for the oil ſwells up greatly, and its boiling over into the fire would be very dangerous. When it boils it is kept ſtirring with an iron ladle; and if it do not itſelf take fire, it is kindled with a piece of flaming paper or wood; for ſimple boiling, without the actual accenſion of the oil, does not communicate a ſufficient degree of the drying quality required. The oil is ſuffered to burn for half an hour or more, and the flame being then extinguiſhed by covering the veſſel cloſe, the boiling is afterwards continued with a gentle heat, till the oil appears of a proper conſiſtence: in which ſtate it

* Lewis's Philoſophical Commerce of Arts.

is called varniſh. It is neceſſary to have two kinds of this varniſh, a thicker and a thinner, from the greater or leſſer boiling, to be occaſionally mixed together, as different purpoſes may require; that which anſwers well in hot weather being too thick in cold, and large characters not requiring ſo ſtiff an ink as ſmall ones.

The thickeſt varniſh when cold may be drawn into threads like weak glue; by which criterion the workmen judge of the due boiling, ſmall quantities being from time to time taken out and dropped upon a tile for this purpoſe. It is very viſcid and tenacious, like the ſoft reſinous juices or thick turpentine. Neither water nor ardent ſpirit diſſolves it; but it readily enough mingles with freſh oil, and unites with mucilages into a maſs diffuſible in water in an emulſive form. Boiling with cauſtic alkali produces a ſoapy compound. It is by waſhing with hot ſoap-lees and a bruſh that the printers clean their types. The oil loſes from one-tenth to one-eighth of its weight by the boiling into the thick varniſh. This loſs ſeems to differ in different ſamples of the ſame kind of oil. Dr. Lewis found that fiſh oil loſt three-fourths of its weight by this treatment, before it acquired the thickneſs produced in linſeed oil.

The workmen are accuſtomed to add in the preparation of ten or twelve gallons of oil, as ſoon as the burning is over, a pound or two of dry cruſts of bread, and a dozen or two of onions, by which they ſuppoſe the greaſineſs to be more effectually deſtroyed. Dr. Lewis, with much appearance of juſtice, doubts the advantage of ſuch additions, and that more eſpecially, as he prepared the varniſh ſeemingly of a good quality by the fire alone. There are other additions of more evident effect, namely, turpentine or litharge, both which are occaſionally uſed. The turpentine is boiled firſt by itſelf to a ſtate nearly of reſin, and the oil being taken from the fire, the hot fluid turpentine is poured in, and the boiling then continued to the proper point. This is ſomewhat difficult to attain, becauſe the mixture is more diſpoſed to grow too thick if overboiled; and is full of little hard grains, probably of reſin, if not ſufficiently boiled. It is affirmed that varniſh containing either turpentine or litharge, particularly the latter, is more adheſive than other varniſh, and preſents a great difficulty in cleaning the types, which ſoon become clogged. Very old oil requires neither of theſe additions. New oil can hardly be brought into a proper ſtate for drying, ſo as not to ſet off, without the uſe of turpentine.

Lamp black is the common material to give the black colour, of which two ounces and a half are ſufficient for ſixteen ounces of the varniſh. Vermilion is a good red. They are ground together on a ſtone with a muller, in the ſame manner as oil paints.

The ink uſed by copper-plate printers differs in the oil, which is not ſo much boiled as to acquire the adheſive quality. This would render it leſs diſpoſed to enter the cavities of the engraving, and more difficult either to be ſpread or wiped off. The black is likewiſe of a different kind. Inſtead of lamp black or ſublimed charcoal, the Frankfort black is uſed, which is a reſidual or denſer charcoal, ſaid to be made from vine-twigs. This is ſofter and leſs gritty than the ivory or other blacks prepared among us, and no doubt contains more coal than any animal reſidue, as all theſe abound with phoſphorated lime. It is ſaid that lamp black gives always a degree of toughneſs to the ink, which the Frankfort black does not; but the goodneſs of the colour ſeems to be the leading inducement for the uſe of the latter. A pale or brown black can be much more eaſily endured in a book than in the impreſſion of an engraving.

We

We have no good explanation of what happens with regard to the chemical effect of boiling and burning upon the oil for printers' uſe.

Common ink for writing is made by adding an infuſion or decoction of the nut gall to martial vitriol, diſſolved in water. A very fine black precipitate is thrown down, the ſpeedy ſubſidence of which is prevented by the addition of a proper quantity of gum arabic. This is uſually accounted for by the ſuperior affinity of the acid of galls, which combining with the iron, takes it from the vitriolic acid, and falls down. But it appears as if this were not the ſimple ſtate of the facts; for the vitriolic acid in ink is not ſo far diſengaged as to act ſpeedily upon freſh iron, or give other manifeſtations of its preſence in an uncombined ſtate.

M. Ribaucourt * has paid particular attention to the proceſs for making black ink. In his experiments the dark coloured rough galls, called Aleppo galls, were uſed, which are the beſt.

He poured a ſolution of mild vegetable alkali (potaſſe) upon a ſtrong decoction of three ounces of galls, which precipitated nine drams of a grey earth ſoluble with effervescence in acids. The ſupernatant fluid was turbid, but the addition of a ſmall quantity of the alkali threw down a little brown matter, after which the liquor became of a fine clear green. This liquid being evaporated to dryneſs and calcined, afforded a very white vitriolated tartar by lixiviation.

Hence he concludes that the nut gall, beſides the colouring matter, contains three drams per ounce of calcareous earth, with a portion of vitriolic acid, but that the vitriolic acid not being ſufficient to ſaturate the earth, the remaining portion was originally ſuſpended by the aſtringent principle, or acid of galls.

In the next place he poured a ſolution of one pound of martial vitriol into a ſtrong decoction of one pound of nut galls. He diluted the mixture with ſo much water, as in the whole made forty pounds, and left the mixture at reſt.

At the end of twenty-four hours the liquid was coloured of a very deep blackiſh purple. Upon decantation, there was found at the bottom of the veſſel a very coarſe precipitate, harſh to the touch, which being collected on the filter and dried, was of a greyiſh blue colour, very compact, brittle, and ſhining in its fracture. Its weight was † eleven ounces and a half.

Forty pounds of water were poured to the decanted fluid, which was again left at reſt for twenty-four hours. Its colour was then found to be much feebler. A new depoſition had been made, which was ſeparated as before and dried. It was of a purpliſh blue, rare and friable between the fingers, granulated and dull in its fracture. Its weight was four ounces two drams.

Forty pounds more of water were added to the decanted liquor, and after twenty-four hours ſubſidence it was perfectly diſcoloured, and exhibited no ſign of the preſence of iron, either by the agency of nut galls, or Pruſſian acid; nor of earth by the addition of an alkali. The precipitate which had ſubſided was light, rare, of a blue leſs purple and more black than the ſecond precipitate; ſofter to the touch while wet, and lighter and more friable when dry. It weighed two ounces two drams.

* Annales de Chimie, xv. 113.

† I tranſlate *livres*, *onces*, and *gros*, by pounds, ounces, and drams. For though the Paris pound is to our Avoirdupois pound, as 7560 to 7000, the number of grains in each, yet the ſubdiviſion being numerically the ſame, the reſults will not be altered by omitting the reduction.

Theſe additional precipitates, obtained by means of dilution with water, would have been very embarraſſing to M. de Ribaucourt, if he had not before experienced a ſimilar decompoſition of alum, which he ſays depoſits its earth entirely by the addition of one hundred and ninety-five parts of water. By a direct experiment he found, that ſix hundred and eighty-one parts of water decompoſe one of vitriol of iron.

From theſe facts he infers, that the calcareous earth of the galls unites with the vitriolic acid of the vitriol, and forms ſelenite, moſt of which falls down with the firſt precipitate, on account of its inſolubility in water; while the calx of iron combines with the colouring matter of the galls, and forms the black fecula which ſubſides more ſlowly.

The blue colour of the three precipitates obtained in the firſt ſet of experiments, naturally directed M. R.'s attention to the theory of Pruſſian blue; and that the more eſpecially, as theſe precipitates were acted upon with difficulty by acids. This action has indeed been conſidered as a proof that the colouring matter is not the ſame in Pruſſian blue, which is inſoluble in acids, and the coloured iron in ink, which is taken up, though ſlowly. But M. Ribaucourt had recourſe to the common proceſs of combining the colouring matter with an alkali.

The firſt of the three precipitates placed over a gentle fire, with an alkaline ſolution (mild I ſuppoſe), ſhewed a conſiderable effervescence as ſoon as the fluid became warm. This he aſcribes to the decompoſition of the ſelenite, which muſt have expelled fixed air from the alkali. The fluid aſſumed a reddiſh colour.

The ſecond precipitate, treated in the ſame manner, ſhewed ſcarcely any effervescence, and the colour of the fluid was deeper.

The third did not effervesce, and the colour was nearly the ſame as the preceding.

Each of theſe ſolutions, after filtration and dilution with water, afforded Pruſſian blue, by the addition of vitriol of iron.

Logwood was found to be an uſeful ingredient in ink, becauſe its colouring matter is diſpoſed to unite with the calx of iron, and renders it not only of a very dark colour, but leſs capable of change from the action of acids, or of the air.

Vitriol of copper in a certain proportion was found to give depth and firmneſs to the colour of the ink. Gum arabic, or other pure gums, was of ſervice, by retarding the precipitation of the fecula; by preventing the ink from ſpreading or ſinking into the paper, and by affording it a kind of compact varniſh, or defence from the air, when dry. Sugar appeared to have ſome bad qualities, but was of uſe in giving a degree of fluidity to the ink, which permitted the doſe of gum to be enlarged beyond what the ink would bear without it. Water proved to be the beſt ſolvent.

Lewis * had ſuppoſed that the defects of ink ariſe chiefly from a want of colouring matter. But the theory, grounded on the facts diſcovered by M. Ribaucourt, requires that none of the principles ſhould be in exceſs. If there be a want of the matter of the galls, part of the vitriol will not be decompoſed; if, on the contrary, there be too much, the vitriol will take as much as it can decompoſe, and the remainder will be nearly in the ſtate of the decoction of galls, ſubject to change by becoming mouldy, or to undergo an alteration after writing,

* Philoſoph. Commerce of Arts.

which

which deſtroys its legibility much more completely than the change undergone by ink containing too ſmall a proportion of the galls.

It is doubtful whether the principles of the galls are well extracted by cold maceration; and it is certain that inks made in this way flow pale from the pen, and are not of ſo deep a black as thoſe wherein ſtrong boiling is recurred to.

From all the foregoing conſiderations Mr. R. gives theſe directions for the compoſition of good ink:

Take eight ounces of Aleppo galls (in coarſe powder); four ounces of logwood (in thin chips); four ounces of vitriol of iron; three ounces of gum arabic (in powder); one ounce of * vitriol of copper, and one ounce of ſugar candy. Boil the galls and logwood together in twelve pounds of water for one hour, or till half the liquid has evaporated. Strain the decoction through an hair ſieve, or linen cloth, and then add the other ingredients. Stir the mixture till the whole is diſſolved, more eſpecially the gum; after which leave it to ſubſide for twenty-four hours. Then decant the ink, and preſerve it in bottles of glaſs or ſtone ware, well corked.

On the ſubject of this memoir of M. Ribaucourt I muſt remark, that though it is highly valuable for the intereſting facts it contains, and others to which it points, yet the chemical reader will be in a certain degree diſſatisfied with the looſe narrative form in which he gives ſome of his reſults, inſtead of the cloſe and orderly method of the German chemiſts. The nature of the earth thrown down by an alkali from the decoctions of galls, that of the ſalt obtained by lixiviation of the ſupernatant fluid; whether the precipitate from alum by mere water was pure argillaceous earth, or only embryon alum; whether the Pruſſian blue thrown down from his alkali, after digeſtion with the atramentous precipitate, ſtood the uſual teſts, &c. theſe and other queſtions preſent themſelves for reſolution from facts, which the ingenious author has omitted fully to ſtate; and from this uncertainty we are diſpoſed rather to invite the philoſophical chemiſt to repeat and extend this important ſeries of experiments, than to rely implicitly upon them.

Dr. Lewis uſes vinegar for his menſtruum; and M. Ribaucourt has vitriol of copper among his ingredients. I have found an inconvenience from the uſe of either, which, though it does not relate to the goodneſs of the ink, is ſufficiently great, in their practical exhibition, to forbid their uſe. The acid of the vinegar acts ſo ſtrongly upon the pen, that it very frequently requires mending; and the vitriol of copper has a ſtill more unpleaſant effect on the penknife. It ſeldom happens when a pen requires mending that the ink is wiped very perfectly from it; and often when the nib only is to be taken off, it is done without wiping at all. Whenever this is the caſe, the ink immediately depoſits a film of copper upon the knife, and by ſuperior elective attraction of the vitriolic acid, a correſpondent portion of the edge of the knife is diſſolved, and is by this means rendered incapable of cutting till it has been again ſet upon the hone.

Inks of other colours may be made from a ſtrong decoction of the ingredients uſed in dying, mixed with a little alum and gum arabic. For example, a ſtrong decoction of Brazil wood, with as much alum as it can diſſolve, and a little gum, forms a good red ink. Theſe proceſſes conſiſt in forming a lake, and retarding its precipitation by the gum. See LAKE.

* See the objection in the next paragraph but one.

Among the amuſing experiments of the art of chemiſtry, the exhibition of ſympathetic inks holds a diſtinguiſhed place. With theſe the writing is inviſible, until ſome reagent gives it opacity. We ſhall here mention a few out of the great number, that a ſlight acquaintance with chemiſtry may ſuggeſt to the ſtudent. 1. If a weak ſolution of galls be uſed, the writing will be inviſible till the paper be moiſtened with a weak ſolution of vitriol of iron. It then becomes black, becauſe theſe ingredients form ink. 2. If paper be ſoaked in a weak ſolution of galls, and dried, a pen dipped in the ſolution of vitriol will write black on that paper, but colourleſs on any other paper. 3. The diluted ſolutions of gold, ſilver, or mercury, remain colourleſs upon the paper, till expoſed to the ſun's light, which gives a dark colour to the calxes, and renders them viſible. 4. Moſt of the acids or ſaline ſolutions being diluted, and uſed to write with, become viſible by heating before the fire, which concentrates them, and aſſiſts their action on the paper. 5. Diluted Pruſſian alkali affords blue letters when wetted with the ſolution of martial vitriol. 6. The ſolution of cobalt in aqua regia, when diluted, affords an ink which becomes green when held to the fire, but diſappears again when ſuffered to cool. This has been uſed in fanciful drawings of trees, whoſe green leaves appeared when warm, and vaniſhed again by cold. This effect has not been explained. If the heat be continued too long after the letters appear, it renders them permanent.

Sympathetic inks have been propoſed as the inſtruments of ſecret correſpondence. But they are of little uſe in this reſpect, becauſe the properties change by a few days remaining on the paper; moſt of them have more or leſs of a tinge when thoroughly dry; and none of them reſiſt the teſt of heating the paper till it begins to be ſcorched.

INSECTS. Various important products are obtained from inſects. The chief are, 1. CANTHARIDES. 2. MILLIPEDES. 3. COCHENILLE, or COCHINEAL. 4. KERMES. 5. LAC. 6. SILK. 7. WAX. For all which the ſeveral titles may be conſulted.

INSTRUMENTS, CHEMICAL. See BALANCE, THERMOMETER, APPARATUS, LABORATORY.

INTERMEDIUM, or MEDIUM. When two chemical principles, which are not diſpoſed to unite, are made to enter into a triple compound, by the addition of a third, this laſt is frequently called the medium, or intermedium. Thus fat oils are made to unite with water by the intermedium of a pure alkali, which converts the oil into ſoap.

IRON. Is a metal of a blueiſh white colour, of conſiderable hardneſs and elaſticity; very malleable, exceedingly tenacious and ductile, and of a moderate ſpecific gravity among metallic ſubſtances. It is much diſpoſed to ruſt by the acceſs of air, or the action of water, in the common temperature of the atmoſphere. The appearance of priſmatic colours on its poliſhed ſurface takes place long before ignition; and at ſo low a temperature, that the ſlighteſt coating of greaſe is ſufficient to prevent their appearance by defending it from the contact of air. It may be ignited, or at leaſt rendered ſufficiently hot to ſet fire to brimſtone, by a quick ſucceſſion of blows with a hammer. When ſtruck with a flint, or other hard ſtone, it emits decrepitating ignited particles, ſuch as can be obtained from no other metal by the ſame means. Theſe particles are ſeldom larger than the two hundredth part of an inch in diameter; and when examined by a magnifier, are found to be hollow, brittle, and of a greyiſh colour, reſembling the ſcales of burned iron. This metal is eaſily calcined by fire. A piece of

of iron wire, immerſed in a jar of vital air, being ignited at one end, will be entirely conſumed by the ſucceſſive combuſtion of its parts. It requires a moſt intenſe heat to fuſe it; on which account it can only be brought into the ſhape of tools and utenſils by hammering. This high degree of infuſibility would deprive it of the moſt valuable property of metals, namely, the uniting of ſmaller maſſes into one, if it did not poſſeſs another ſingular and advantageous property, which is found in no other metal except platina; namely, that of welding. In a white heat, iron appears as if covered with a kind of varniſh; and in this ſtate, if two pieces be applied together, they will adhere, and may be perfectly united by forging. Iron is thought to be the only ſubſtance in nature which has the property of becoming magnetical. It is highly probable, from the great abundance of this metal, that all ſubſtances which exhibit magnetiſm do contain iron; but it muſt be confeſſed that there remain many experiments to be made among the earths and powders which exhibit magnetical properties, before this negative propoſition, which confines magnetiſm to iron, can be admitted as proved.

When iron is expoſed to the action of pure water, it acquires weight by gradual calcination, and inflammable air eſcapes: this is a very ſlow operation. But if the ſteam of water be made to paſs through a red-hot gun barrel, or through an ignited copper or glaſs tube, containing iron wire, the iron becomes converted into a calx; while inflammable air paſſes out at the other end of the barrel. This capital experiment * may be accounted for according to the ancient and modern theories. In the ancient theory, it is ſuppoſed that the water has combined with the iron, and diſengaged its phlogiſton in the form of inflammable air; and conſequently that, when this calx is again revived by heating a portion of it in inflammable air with a burning glaſs, and water appears, at the ſame time that part of the inflammable air is abſorbed, the iron has imbibed phlogiſton, and given out its water. Clear as this explanation appears to be, the ſolution afforded by the modern theory is not leſs perſpicuous. The maintainers of this theory reaſon as follows: Iron has not been ſhewn to be a compound ſubſtance; let us therefore conſider it as a ſimple ſubſtance, until we poſſeſs experiments which ſhew the contrary. Water has been ſhewn to be a compound ſubſtance, by the experiment of its production, by burning dephlogiſticated and inflammable air together. We may fairly therefore affirm, that the inflammable air came from the water, in which we know it to exiſt; and that the vital air of the water, the peculiar inſtrument of calcination, has combined with the iron. On the other hand, when the iron is revived in inflammable air, the water which appears is the very product of combination which was decompoſed in the former inſtance. For the vital air quits the iron to unite in the fluid ſtate with the inflammable air; and the iron being ſet at liberty, recovers its original ſtate; that is to ſay, it is revived.

That the iron, in the one inſtance, attracts vital air from the water, and diſengages inflammable air; and, in the other inſtance, exhibits a leſs affinity with that ſubſtance, ſo as to reſtore it to its former combination; is a difficulty which, in the preſent ſtate of our information, can only be accounted for by ſuppoſing that the temperature in the furnace differs from that produced by the burning glaſs; and that theſe affinities, like moſt others in chemiſtry, are not the ſame at all temperatures. This difficulty affects both theories alike; for it is not eaſier

* Of M. Lavoiſier.

to

to account for the contrary tranſitions of water and phlogiſton, which mutually expel each other in the old theory, than for the tranſitions of dephlogiſticated and inflammable air in the new theory.

The philoſophers who reject phlogiſton inſiſt, moreover, that the weight of the inflammable air produced, being deducted from the weight of the water made uſe of, leaves a quantity equal to the increaſe the iron gains by calcination; and that by burning the whole inflammable air produced, with a quantity of vital air equal in weight to the gain of the iron, a new quantity of water is recompoſed, which is equal likewiſe to that made uſe of. Hence they urge, that it is infinitely more probable that the inflammable air came from the water than from the iron. The latter fact, of the recompoſition, is in their favour; but the former is not. For whatever the inflammable air comes from, the firſt equation will be true; that is to ſay, if the iron give out phlogiſton, and receive water, its acceſſion of weight will be equal to the difference between the water it has received, and the phlogiſton it has loſt; but the reproduction of the water loſt will ſhew that the inflammable air really correſponds with the quantity required to form* ſo much water, if we admit the accuracy of the experiments.

The concentrated vitriolic acid ſcarcely acts on iron, unleſs it be boiling. When the acid is diſtilled to dryneſs from this metal, the retort is found to contain ſublimed flowers of ſulphur, and a white vitriolic maſs, partly ſoluble in water: the product which comes over is volatile vitriolic acid, and vitriolic acid air. If the vitriolic acid be diluted with two or three parts of water, it diſſolves iron readily, without the aſſiſtance of any other heat than is produced by the act of combination. During this ſolution, inflammable air eſcapes in large quantities. If heat be applied, the acid proceeds to diſſolve more iron, and depoſits a white ſaline maſs, or pale vitriol of iron.

The combination of vitriolic acid and iron, called martial vitriol, is much more ſoluble in hot than cold water; and therefore cryſtallizes by cooling, as well as by evaporation. The cryſtals are effloreſcent, and fall into a white powder by expoſure to a dry air, the iron becoming more calcined than before. A ſolution of martial vitriol, expoſed to the air, imbibes its vital part; and a portion of the iron, becoming too much calcined to adhere to the acid, falls to the bottom in the form of ochre. The ſolution, as well as the cryſtals it affords by evaporation, are thus rendered paler than before.

Martial vitriol is not made in the direct way, becauſe it can be obtained at leſs charge from the decompoſition of martial pyrites.

The different appearances which accompany the ſolutions of iron in the vitriolic acid, may be accounted for according to the principles either of the ancient or modern theories. In the ancient theory, the iron, being ſuppoſed to contain phlogiſton or the principle of inflammability, is calcined in both caſes; that is

* It may be urged that the two airs contain much water; and for that, as well as other reaſons, their abſolute quantities cannot be aſcertained. But it is not required to aſcertain their abſolute quantities: for it is enough if the two airs in this recompoſition be exactly in the ſame ſtate as in the original experiment, by which the component parts of water were determined. If a certain portion of water be neceſſary to inflammable air in the elaſtic ſtate, it muſt of courſe take it from the ſteam in the gun-barrel at the inſtant of its extrication, and not afterwards from the water of the receivers: this requires to be confirmed by an experiment over mercury. How far Dr. Prieſtley's experiments (Phil. Tranſ. lxxviii and lxxix) may affect the poſition, that water is a compound ſubſtance, cannot be clearly aſcertained until it is ſhewn that the acid produced in burning the two airs does not ariſe from impurity in one or both of them.

to

to ſay, it gives out phlogiſton*. With the concentrated acid the ſolution does not take place; becauſe the capacity of the mixture for heat, and conſequently its abſolute quantity of heat, is too ſmall to ſupply what the increaſed capacity of the vitriolic acid air would require, and conſequently the iron is not decompoſed. But when heat is applied, the phlogiſton of the iron uniting with the baſis of part of the acid, forms ſulphur; which, together with another portion of the acid, riſes in the form of vitriolic acid air; at the ſame time that the vital air of the decompoſed acid unites with the calx of iron, which becomes ſoluble in the acid that remains; but when much water is preſent, as in the diluted acid, the heat is ſupplied from the great capacity of the water; the phlogiſton of the iron aſſumes the elaſtic form; and inflammable air flies off, while the acid unites with the calx of iron, and forms vitriol. The decompoſition of the acid in the former, and not in the latter caſe, is accounted for from its ſtrong attraction to the water. A conſiderable heat, applied with the diluted acid, calcines the iron more perfectly; which then either enters into the compoſition of pale vitriol, containing a larger proportion of acid, or falls down in the form of calx. The acceſs of air does the ſame thing more gradually.

In the antiphlogiſtic theory, iron is aſſumed to be a ſimple ſubſtance; vitriolic acid is ſaid to be compoſed of vital air and ſulphur; and water is admitted to be decompoſable. When iron therefore is applied to concentrated vitriolic acid, the principles retain their order of combination at a common temperature; but as ſoon as the temperature is raiſed, the iron becomes calcined, by attracting vital air from part of the acid, whoſe ſulphur is therefore ſet at liberty, and flies off with another portion of the acid, in the form of vitriolic air; while the remaining acid combines with part of the calx. But when the acid is more diluted, the water itſelf is decompoſed; its inflammable air is diſengaged; its vital air unites with, and calcines the iron; and the vitriolic acid diſſolves the calx.

The neceſſity of heat being applied to the concentrated ſolution in the one caſe rather than the other, may be referred to the capacities of the bodies before and after the change, in either theory. But it muſt be confeſſed, that the cauſe of the diſengagement of vitriolic air in the one caſe, and inflammable in the other, is not ſo well ſolved. It has not been explained, upon the old theory, why the phlogiſton in one caſe unites with the acid, and forms ſulphur, and in the other flies off alone; neither has it been ſhewn, in the new theory, why the water ſhould not be decompoſed in the former inſtance, as well as the latter.

The further calcination of the iron by heat, or by expoſure of the ſolution to the air, is accounted for, in the new theory, from the abſorption of more vital air. The general fact, that a definite degree of calcination is neceſſary for the moſt perfect ſolution of metals in acids, depends on attractions which have not been experimentally reſolved; but which, in the way of conjecture, may be as eaſily accounted for by one theory as by the other.

Vitriol of iron is decompoſed by alkalis and by lime. Cauſtic fixed alkali precipitates the iron in deep green flocks, which are diſſolved by the addition of more alkali, and form a red tincture. The mild alkali does not re-diſſolve the precipitate it throws down, which is of a greeniſh white colour. Diſ-

* Kirwan, in Philoſ. Tranſact. vol. lxxii; and Eſſay on Phlogiſton, London, 1789, page 62, or page 28 of the old edition.

tillation

tillation ſeparates the acid from martial vitriol, and leaves the brown calx of iron, called colcothar.

Vegetable aſtringent matters, ſuch as nut-galls, the huſks of nuts, logwood, tea, &c. which contain the acid of galls hereafter to be deſcribed, precipitate a fine black fecula from martial vitriol, which remains ſuſpended for a conſiderable time in the fluid, by the addition of gum arabic. This fluid is well known by the name of ink. See INK.

The beautiful pigment, well known in the arts by the name of Pruſſian blue, is likewiſe a precipitate afforded by martial vitriol. See BLUE PRUSSIAN; alſo ACID OF PRUSSIAN BLUE.

Concentrated nitrous acid acts very ſtrongly upon iron filings, much nitrous air being diſengaged at the ſame time. The ſolution is of a reddiſh brown, and depoſits the calx of iron after a certain time; more eſpecially if the veſſel be left expoſed to the air. A diluted nitrous acid affords a more permanent ſolution of iron, of a greeniſh colour, or ſometimes of a yellow colour; neither of the ſolutions affords cryſtals; but both depoſit the calx of iron by boiling, at the ſame time that the fluid aſſumes a gelatinous appearance. This magma, by diſtillation, affords fuming nitrous acid, much nitrous air, and ſome phlogiſticated air; a red calx being left behind, which, in all probability, retains moſt of the vital air of the acid.

If vegetable alkali be added to the nitrous ſolution of iron, a brown precipitate falls down; of which a ſmall quantity is rediſſolved by the alkali. Mild vegetable alkali ſeparates a yellowiſh calx, which ſoon becomes of a beautiful orange red colour. If the mixture be agitated during the effervеſcence, the precipitate is re diſſolved in much greater quantity than by the pure vegetable alkali; doubtleſs by the medium of the fixed air. This ſolution is known by the name of Stahl's martial alkaline tincture, and is of a fine red colour, which however is impaired by time. Pure volatile alkali ſeparates a deep green and almoſt black precipitate from the nitrous ſolution of iron. The mild volatile alkali re-diſſolves the iron, which it ſeparates from the acid; and forms an alkaline tincture of a more lively colour than that of Stahl.

Diluted marine acid rapidly diſſolves iron, at the ſame time that a large quantity of inflammable air is diſengaged, and the mixture becomes hot. In this, as well as in the vitriolic ſolution of iron, the ſame quantity of alkali is ſaid to be required to ſaturate the acid as before the ſolution; whence it is inferred, that the acid is not decompoſed, but that the calcination is effected by the vital air of the water; whence alſo it appears to follow, that the inflammable air muſt be afforded from the decompoſed water, and not from the metal. It muſt however be remarked, that this fact, as well as moſt of thoſe upon which the rejection of phlogiſton, or the inflammable principle, is grounded, are controverted by the philoſophers who maintain the exiſtence of that principle.

The marine ſolution of iron is of a yellowiſh green colour, and is much more permanent than the ſolutions of that metal in the vitriolic or nitrous acids; though, like all the other ſolutions of iron, it depoſits its metal by expoſure to the air. By evaporation it aſſumes the conſiſtence of ſyrup; in which, needle-formed and deliqueſcent cryſtals appear. Some chemiſts affirm, that the acid quits the iron by diſtillation, though much more difficultly than either the nitrous or vitriolic acid; but this intereſting experiment has not been made ſince the improvements of chemiſtry have led philoſophers to attend to ſuch products as appear in the permanently elaſtic ſtate.

The marine ſolution of iron is decompoſed by lime and by alkalis; but the precipitates are more eaſily reduced to the metallic ſtate than thoſe afforded by other acids. Liver of ſulphur, hepatic air, and aſtringents, decompoſe this, as well as the other ſolutions of iron; and the pure Pruſſian alkali throws down a very fine blue precipitate.

Fixed air, diſſolved in water, combines with a conſiderable quantity of iron, in proportion to its maſs. Vinegar ſcarcely diſſolves it, unleſs by the aſſiſtance of the air.

In the dry way, this metal does not combine with earths, unleſs it be previouſly calcined; in which caſe it aſſiſts their fuſion, and imparts a green colour to the glaſs. It appears to combine with alkalis by fuſion. Nitre detonates ſtrongly with it, and becomes alkalized. Sal ammoniac is decompoſed by it. Two parts of iron filings, triturated with one part of ſal ammoniac, and expoſed to diſtillation, afford about one part of liquid volatile alkali, contaminated by a ſmall portion of iron. Some inflammable air comes over in this diſtillation, either from the iron or from the water contained in the ſal ammoniac; the reſidue conſiſts of iron, united to marine acid. A medical preparation is made by ſubliming ſal ammoniac from a ſmall portion of iron filings; which gives part of the ſalt a yellow colour. The calx of iron decompoſes ſal ammoniac by ſeizing its acid, even in the cold.

Sulphur combines very readily with iron, in the dry and even in the humid way, though neither of theſe ſubſtances is ſcarcely at all ſoluble in water. A mixture of iron filings and flowers of ſulphur being moiſtened, or made into a paſte, with water, becomes hot, ſwells, adheres together, breaks, and emits watery vapours of an hepatic ſmell. If the mixture be conſiderable in quantity, as for example, one hundred pounds, it takes fire in twenty or thirty hours, as ſoon as the aqueous vapours ceaſe. This effect may be explained without difficulty in a general way, though the circumſtances require to be more minutely examined:—Iron, ſulphur and water, are placed in contact. The iron is very ſparingly ſoluble in water*; and the ſulphur is probably ſoluble in a ſmall degree, as may be judged by its becoming ſoft in that fluid. In the ancient theory, it may be ſaid that the ſulphur combines with the calx of the iron, and expels its inflammable air or phlogiſton. The heat muſt be deduced, in any theory, from the change of capacity, or rapid commotion, produced in the act of union. This heat volatilizes part of the ſulphur, together with the inflammable air; and if the temperature be ſufficiently elevated, theſe ſubſtances will take fire, at the moment of their extrication, by the aſſiſtance of the air of the atmoſphere. In the new theory, the explanation will be nearly the ſame. The iron and the ſulphur, being conſidered as ſimple ſubſtances, tend to combine with each other, through the medium of vital air, which calcines the iron, and is ſuppoſed to be afforded by decompoſition of the water. The ſame decompoſition extricates inflammable air from the water. This, together with the ſulphur, forms hepatic air; which flying off at the temperature of ignition, takes fire by combination with the air of the atmoſphere. In this theory it may further be added, that, as ſulphur and water, in contact, at an elevated temperature, afford inflammable air, which is explained by the ſuppoſition of vital air combining with the ſulphur, there would be an increaſe of inflammation from this cauſe. Some doubt however may be entertained, whether ſulphur be more combuſtible

* Annales de Chimie, vol. i. 220.

than inflammable air at any temperature, ſince hepatic air depoſits ſuphur when detonated with vital air; which muſt, in all probability, depend on the latter being leſs combuſtible at the temperature of inflammation. On the whole, it appears, that facts and obſervations are wanting, rather than probable theories; and that it is ſcarcely neceſſary to purſue this inquiry more minutely in the way of argumentative diſquiſition. The ſpontaneous combuſtion of iron and ſulphur with water, is evidently an effect of the ſame kind as the decompoſition of pyrites.

Sulphur combines very readily with iron by fuſion; and produces a compound of the ſame nature as the pyrites, and exhibiting the ſame radiated ſtructure when broken. If a bar of iron be heated to whiteneſs, and then touched with a roll of ſulphur, the two ſubſtances combine, and drop down together in a fluid ſtate. It is neceſſary that this experiment ſhould be made in a place where there is a current of air to carry off the fumes; and the melted matter, which may be received in a veſſel of water, is of the ſame nature as that produced by fuſion in the common way, excepting that a greater quantity of ſulphur is fuſed by the contact of the bar of iron. The experiment of combining iron and ſulphur together by fuſion, has not been made with an attention to the volatile products, if any be extricated. As neither of theſe ſubſtances contains water, and both are ſuppoſed, in the new theory, to be ſimple bodies, the experiment might, perhaps, afford an intereſting reſult.

If equal parts of phoſphoric glaſs, and iron clippings, together with one-ſixteenth of a part of pulverized charcoal, be fuſed together, the mixture is very brittle, white in its fracture, and of a ſtriated and granulated texture. This combination of iron with phoſphoric acid is found in the iron produced from bog ores, which abound in the remains of decayed vegetables. It is the cauſe of brittleneſs in the iron when cold, which occaſions that kind of iron to be called cold ſhort iron by the workmen. Phoſphorated iron was at firſt taken to be a peculiar metal, and was called ſiderite by Bergman.

Iron unites with gold, ſilver, and platina. When heated to a white heat, and plunged in mercury, it becomes covered with a coating of that metal. Long trituration of mercurial amalgams likewiſe cauſes a coating to adhere to the ends of iron peſtles; ſmall ſteel ſprings, kept plunged beneath the ſurface of mercury in certain barometers, become brittle in proceſs of time; and the direct combination of * iron and mercury in the form of an amalgam, may be obtained by triturating the filings with twice their weight of alum, then adding an equal weight or more of mercury, and continuing the friction, with a very ſmall quantity of water, till the union is completed. Iron and tin very readily unite together, as is ſeen in the art of tinning iron veſſels, and in the fabrication of thoſe uſeful plates of iron, coated with tin, which are generally diſtinguiſhed by the ſimple name of tin alone. The chief art of applying thoſe coatings of tin, conſiſts in defending the metals from calcination by the acceſs of air. After the iron plates are ſcraped, or rendered very clean by ſcouring with an acid, they are wetted with a ſolution of ſal ammoniac, and plunged into a veſſel containing melted tin, the ſurface of which is covered with pitch or tallow, to preſerve it from calcination. The tin adheres to, and intimately combines with the iron to a certain depth, which renders the tinned plates leſs diſpoſed to harden by hammering, than before, as well as much leſs diſpoſed to alter, by the united action

* Vogell in Crell's Annals, ii. 103. Eng. tranſ.

of air and moiſture. The proceſs for tinning of iron veſſels does not eſſentially differ from that which has already been deſcribed of copper veſſels. Iron does not unite with biſmuth, at leaſt in the direct way. As nickel cannot be purified from iron without the greateſt difficulty, it may be preſumed that theſe ſubſtances would readily unite, if the extreme infuſibility of both did not preſent an obſtacle to the chemical operator. Arſenic forms a brittle ſubſtance in its combination with iron. This ſemi-metal, which is ſo abundant in the mineral kingdom, is ſaid to be the cauſe of the brittleneſs, which ſome ſpecimens of iron poſſeſs when hot, though malleable when cold. Iron thus contaminated, is diſtinguiſhed by workmen, by the name of red ſhort iron. Cobalt forms a hard mixture with iron, which is not eaſily broken. The inflammability and volatility of zinc preſent an obſtacle to its combination with iron. It is not improbable, however, but that clean iron filings would unite with zinc, if that metal were kept in contact with them for a certain time, in a heat not ſufficient to cauſe it to riſe; for it has been found that zinc may be uſed in the operation of coating iron in the ſame manner as tin. Antimony unites with iron, and forms a hard brittle combination, which yields in a ſlight degree to the hammer. The combination of ſulphur and the regulus of antimony, which is commonly known by the name of antimony, is decompoſed by virtue of the greater affinity of the iron to the ſulphur. For this purpoſe, five ounces of the points of nails from the farriers may be made red hot in a crucible, one pound of pulverized ore of antimony muſt then be thrown into the crucible, and the heat quickly raiſed to fuſe the whole. When the fuſion is perfect, an ounce of nitre in powder may be thrown in, to facilitate the ſeparation of the ſcoriæ. After the maſs is cooled, the antimony is found ſeparate at the bottom of the crucible, while the iron remains in combination with the ſulphur and alkali. If the proportion of the iron be conſiderably greater than five ounces to the pound of antimonial mineral, the regulus will be alloyed with iron. Manganeſe is almoſt always united with iron in the native ſtate. Wolfram forms a brittle whitiſh-brown hard alloy, of a compact texture, when fuſed with white crude iron.

The habitudes of iron with the regulus of molybdena are not known.

Iron is the moſt diffuſed, and moſt abundant, of metallic ſubſtances. Few mineral bodies, or ſtones, are without an admixture of this metal. Sands, clays, and the waters of rivers, ſprings, rain, or ſnow, are ſcarcely ever perfectly free from it. The parts of animal and vegetable ſubſtances likewiſe afford iron in the reſidues they leave after incineration. It has been found native, in large maſſes, in Siberia*, and in the internal parts of South America. This metal however in its native ſtate is ſcarce: moſt iron is found in the calciform ſtate, in ochres, bog ores, and other friable earthy ſubſtances, of a red, brown, yellow, or black colour. The hamatites, or blood ſtones, are likewiſe calciform ores of iron: theſe are either of a red colour, or blue, yellow, or brown. This uſeful metal is ſo abundant, that whole mountains are compoſed of iron ſtone; whereas, other metals uſually run in ſmall veins. Beſides the calciform ores of iron, which are either nearly pure, or elſe mixed with earths, as in ſpars, jaſper, boles, baſaltes, &c. iron is mineralized with ſulphur, as in the pyrites; or with both. An iron ore is likewiſe found, of a blue colour, and powdery appearance, which is thought to be of the ſame nature as Pruſſian blue. The coaly iron ores

* See Bergman's Eſſays; Magellan's improved edition of Cronſtedt's Mineralogy; and the Phil. Tranſ. lxxviii. 37.

contain bitumen. The magnet, or loadſtone, is an iron ore, whoſe conſtitution has not yet been accurately examined. Iron is alſo found in combination with the vitriolic acid, either diſſolved in water, or in the form of vitriol.

To analyſe the ores of iron in the humid way, they muſt be reduced to a very ſubtle powder, and repeatedly boiled in marine acid. If the ſulphureous ores ſhould prove ſlow of ſolution, a ſmall quantity of nitrous acid muſt be added to accelerate the operation. The iron being thus extracted, the inſoluble part of the matrix only will remain. Pruſſian alkali, being added to the decanted ſolution, will precipitate the iron in the form of Pruſſian blue. This precipitate, when waſhed and dried, will be equal in weight to ſix times the quantity of metallic iron it contains; and from this iron four parts in the hundred muſt be deducted, to allow for the iron which is contained in the Pruſſian alkali itſelf. But as this alkali, and every other preparation containing the Pruſſian acid, does not conſtantly afford the ſame quantity of iron, the moſt exact way, in the uſe of ſuch preparations, conſiſts in previouſly diſſolving a known quantity of iron in vitriolic acid; and precipitating the whole by the addition of the Pruſſian alkali. This reſult will afford a rule for the uſe of the ſame alkali in other ſolutions. For as the weight of the precipitate obtained in the trial experiment, is to the quantity of iron which was diſſolved and precipitated; ſo is the weight of the precipitate obtained from any other ſolution, to the quantity of iron ſought.

If the iron be united to any conſiderable proportion of zinc or manganeſe, the Pruſſian blue muſt be calcined to redneſs, and treated with pale nitrous acid, which will take up the calx of zinc. The manganeſe may then be diſſolved by nitrous acid, with the addition of ſugar; and the remaining iron being diſſolved by marine acid, and precipitated by mild mineral alkali, will afford 225 grains of precipitate for every 100 grains of metallic iron.

To examine the ores of iron in the dry way, the only requiſite is fuſion, in contact with charcoal. For this purpoſe eight parts of pulverized glaſs, one of calcined borax, and half a part of charcoal, are to be well mixed together. Two or three parts of this flux, being mixed with one of the pounded ore, and placed in a crucible, lined with a mixture of a little clay and pounded charcoal, with a cover luted on, is to be urged with the ſtrong heat of a ſmith's forge for half an hour. The weight of the ore, in this experiment, ſhould not exceed 60 grains. Other proceſſes for determining the contents, or metallic product, of iron ores, are inſtituted by performing the ſame operations in the ſmall, as are intended to be uſed in the large way.

In the large iron works, it is uſual to roaſt, or calcine the ores of iron, previous to their fuſion; as well for the purpoſe of expelling ſulphureous or arſenical parts, as to render them more eaſily broken into fragments of a convenient ſize for melting. The mineral is melted, or run down, in large furnaces, from 16 to 30 feet high; and variouſly ſhaped, either conical or elliptical, according to the opinion of the iron maſter. Near the bottom of the furnace is an aperture for the inſertion of the pipe of large bellows, worked by water or ſteam, or of other machines for producing a current of air; and there are alſo holes at proper parts of the edifice, to be occaſionally opened, to permit the ſcoriæ and the metal to flow out, as the proceſs may require. Charcoal, or coke, with lighted bruſh-wood, is firſt thrown in; and when the whole inſide of the furnace has acquired a ſtrong ignition, the ore is thrown in by ſmall quantities at a time, with more of the fuel, and commonly a portion of limeſtone, as a flux: the ore gradually ſubſides into the hotteſt part of the furnace, where it becomes fuſed; the earthy

part

part being converted into a kind of glaſs; while the metallic part is reduced by the coal, and falls through the vitreous matter to the loweſt place. The quantity of fuel, the additions, and the heat, muſt be regulated, in order to obtain iron of any deſired quality; and this quality muſt likewiſe, in the firſt product, be neceſſarily different, according to the nature of the parts which compoſe the ore.

The iron which is obtained from the ſmelting furnaces is not pure; and may be diſtinguiſhed into three ſtates: white crude iron, which is brilliant in its fracture, and exhibits a cryſtallized texture, more brittle than the other kinds, not at all malleable, and ſo hard as perfectly to withſtand the file: grey crude iron, which exhibits a granulated and dull texture when broken; this ſubſtance is not ſo hard and brittle as the former, and is uſed in the fabrication of artillery and other articles which require to be bored, turned, or repaired: and black caſt iron, which is ſtill rougher in its fracture; its parts adhere together leſs perfectly than thoſe of the grey crude iron: this is uſually fuſed again with the white crude iron.

Whenever crude iron, eſpecially the grey ſort, is fuſed again with contact of air, it emits ſparkles, loſes weight, and becomes leſs brittle. In order to convert it into malleable iron, it is placed on a hearth, in the midſt of charcoal, urged by the wind of two pair of bellows. As ſoon as it becomes fuſed, a workman continually ſtirs it with a long iron inſtrument. During the courſe of ſeveral hours it becomes gradually leſs fuſible, and aſſumes the conſiſtence of paſte. In this ſtate it is carried to a large hammer, the repeated blows of which drive out all the parts that ſtill partake of the nature of crude iron ſo much as to retain the fluid ſtate. By repeated heating and hammering, more of the fuſible iron is forced out; and the remainder, being malleable, is formed into a bar or other form for ſale. Crude iron loſes upwards of one-fourth of its weight in the proceſs of refining.

Purified or bar iron is ſoft, ductile, flexible, malleable, and poſſeſſes all the qualities which have been enumerated under this article, as belonging excluſively to iron. When a bar of iron is broken, its texture appears fibrous; a property which depends upon the mechanical action of the hammer, while the metal is cold. Ignition deſtroys this fibrous texture, and renders the iron more uniform throughout; but hammering reſtores it.

If the pureſt malleable iron be bedded in pounded charcoal, in a covered crucible, and kept for a certain number of hours in a ſtrong red heat (which time muſt be longer or ſhorter, according to the greater or leſs thickneſs of the bars of iron), it is found that by this operation, which is called cementation, the iron has gained a ſmall addition of weight, amounting to about the hundred and fiftieth, or the two hundredth part; and is remarkably changed in its properties. It is much more brittle and fuſible than before. Its ſurface is commonly bliſtered when it comes out of the crucible; and it requires to be forged, to bring its parts together into a firm and continuous ſtate. This cemented iron is called ſteel. It may be welded like bar iron; but its moſt uſeful and advantageous property is that of becoming extremely hard when ignited and plunged into cold water. The hardneſs produced is greater in proportion as the ſteel is hotter, and the water colder. The colours which appear on the ſurface of ſteel ſlowly heated, are yelloviſh white, yellow, gold colour, purple, violet, deep blue, yelloviſh white; after which the ignition takes place. Theſe ſigns direct the artiſt in tempering or reducing the hardneſs of ſteel to any determinate ſtandard.

If

If ſteel be too hard, it will not be proper for tools which are intended to have a fine edge, becauſe it will be ſo brittle that the edge will ſoon become notched; if it be too ſoft, it is evident that the edge will bend or turn. Some artiſts ignite their tools, and plunge them into cold water; after which, they brighten the ſurface of the ſteel upon a ſtone: the tool being then laid upon charcoal, or upon the ſurface of melted lead, or placed in the flame of a candle, gradually acquires the deſired colour; at which inſtant they plunge it into water. If a hard temper be deſired, the piece is dipped again, and ſtirred about in the cold water as ſoon as the yellow tinge appears. If the purple appear before the dipping, the temper will be fit for gravers, and tools uſed in working upon metals; if dipped while blue, it will be proper for ſprings, and for inſtruments uſed in the cutting of ſoft ſubſtances, ſuch as cork, leather, and the like; but if the laſt pale colour be waited for, the hardneſs of the ſteel will ſcarcely exceed that of iron. When ſoft ſteel is heated to any one of theſe colours, and then plunged into water, it does not acquire nearly ſo great a degree of hardneſs, as if previouſly made quite hard, and then reduced by tempering. The degree of ignition required to harden ſteel is different in the different kinds. The beſt kinds require only a low red heat. The harder the ſteel, the more coarſe and granulated its fracture will be; and as this is not completely remedied by the ſubſequent tempering, it is adviſeable to employ the leaſt heat capable of affording the requiſite hardneſs. It is a circumſtance worthy of remark, that ſteel has a leſs ſpecific gravity when hardened than when ſoft; but there are no circumſtances, upon which a probable connection between theſe two properties, namely, the increaſed hardneſs and the diminiſhed ſpecific gravity, can be made out.

The uſual time required for the cementation of ſteel, is from ſix to ten hours. If the cementation be continued too long, the ſteel becomes porous, brittle, of a darker fracture, more fuſible, and incapable of being forged or welded. On the contrary, ſteel cemented with earthy infuſible powders, is gradually reduced to the ſtate of forged iron again. Simple ignition produces the ſame effect; but is attended with calcination of the ſurface. The texture of ſteel is rendered more uniform by fuſing it before it is made into bars: this is called caſt ſteel; and is rather more difficultly wrought than common ſteel, becauſe it is more fuſible, and is diſperſed under the hammer if heated to a white heat.

When we conſider the operations by which crude iron is brought into the malleable ſtate, then converted into ſteel, and afterwards into a fuſible metal, which is not malleable; we may perceive that ſteel-making is a kind of inverſion of the proceſs of refining iron, as practiſed in the firſt inſtance. When the calx of iron is mixed together in the ſmelting furnace, with combuſtible matter and glaſs, it will either be completely or partially revived, according to the management of the proceſs. Much of the coal will however be ſo enveloped with the vitreous matter as to remain unburned: and the reduced iron, with which it may be in contact, will be in the ſame ſituation as forged iron in the cementing pot; that is to ſay, it will be in contact with coal at a very elevated temperature, and defended from the air. From the great infuſibility of iron, it may reaſonably be concluded that the reduced metal does not flow into the bottom of the furnace, until the charcoal has converted it into a fuſible matter ſimilar to ſteel, by the ſame action which takes place in cementation, whatever that action may be. Hence it muſt follow, that the various ſpecimens of crude or caſt iron will differ in their qualities, as well on account of the degree of cementation they have undergone, as the degree of reduction which has taken place among the metallic

parts,

parts, which are carried down, and form the whole maſs. Since the coal, in the proceſs of cementation, communicates or adds weight to the iron; and ſince crude iron, as well as ſteel, exhibits ſparkles, and is more eaſily burned than other iron; it may therefore be concluded that, in the proceſs of refining, that part of the inflammable ſubſtance which had united with the metal is burned, and leaves the iron much leſs fuſible than before. Stirring the maſs multiplies the contacts of the air with the burned ſubſtances; theſe ſurfaces of contact will therefore ſucceſſively afford thin coats of infuſible metal. In this manner it is found, that if a large piece of crude iron be expoſed to heat in a wind furnace, the external part will be deprived of its fuſibility during the time required to produce a ſtrong heat in the whole maſs; and the internal part will be melted, and run out, leaving the ſhell behind. Iron which is of the conſiſtence of paſte may therefore be conſidered, like any other paſte, as a mixture of a fluid with a ſolid. It will be eaſily underſtood that the forging will bring the parts of difficult fuſion together, and extrude the leſs refined and fluid parts: it will alſo be evident that this operation is not likely to drive out the whole of the fuſible matter. When the iron has arrived at that ſtate wherein the quantity of fibre or tough iron is ſufficient to anſwer the mechanical purpoſes to which it is intended to be applied, the artiſt will conſider it as ſufficiently refined; and the reſidue of fuſible iron contained in the bar anſwers, in all probability, the valuable purpoſe of connecting theſe infuſible maſſes together. Thus we find that forged iron appears as if covered with a varniſh, when urged to a white heat; we find that this varniſh is more abundant in ſteel; and that iron and ſteel may be reſpectively welded together by application in this ſtate; an effect which it would be very difficult to account for, in this moſt infuſible of metals, if it were not for ſuch an admixture. But caſt ſteel, ſteel over-cemented, and crude iron, appear to be in the ſtate of all other metals, platina excepted. They cannot be welded, becauſe welding implies a partial fuſion; or an effect ſimilar to the glueing or uniting of ſolids by the application of a fluid, which afterwards becomes conſiſtent. And if it be true that platina poſſeſſes this valuable property, it ſeems reaſonable to infer that it muſt alſo conſiſt of two metallic ſubſtances of different degrees of fuſibility.

Crude iron, and ſteel of an uniform texture, conſiſt therefore of a fuſible combination of iron with the combuſtible ſubſtance of the coal, or ſomething which is imparted from it; the crude iron differing from the ſteel ſimply in being over-cemented, and leſs pure, on account of the admixture of metallic calx, which can ſcarcely, perhaps, be avoided in the large proceſs. It appears therefore that crude iron muſt paſs through the ſtate of ſteel before it can become forged iron; and conſequently that the fabrication of ſteel from this laſt is a circuitous proceſs, which can only be repaid by the abſence of thoſe unreduced parts which may exiſt in the crude iron. At ſome forges, however, where the ore, the flux, the fuel, and the management, are adapted to each other, the produce affords ſteel, when duly refined. At other manufactories, the crude iron is either refined, or converted into ſteel, by running it into thin plates, which are ſtratified with charcoal, and burned in a cloſe furnace. In this way the metal is refined by degrees, without undergoing fuſion; and if the heat be raiſed to that of cementation, the iron will not only be reduced, but converted into ſteel. In the forges of Carinthia the grey crude iron is alſo converted either into ſoft iron, or ſteel, according to the management of a ſomewhat ſimilar proceſs. The iron is fuſed in a large

large melting-pot; and a ſmall quantity of water being thrown upon the ſurface of the metal, cauſes a thin plate to congeal, which is taken off; and, by continuing the operation, the greateſt part of the fuſed iron becomes converted into plates. To produce ſteel, theſe plates are again fuſed, and kept a long time in an elevated heat; at the ſame time that the metal is defended from the contact of the air by a ſufficient quantity of the vitreous ſlag. To produce ſoft iron, the plates are expoſed to a continued roaſting, while the air is conſtantly renewed by means of two pair of bellows. The extenſive ſurface of the plates renders it unneceſſary to uſe that agitation, or ſtirring, which is required when fuſed crude iron is refined. In theſe proceſſes it is evident that the ſame matter in the crude iron, which it obtained in the ſmelting furnace, is employed, and ſupplies the place of the charcoal uſed in forming ſteel by cementation; and, on the other hand, that this ſubſtance, which prevented the crude iron from being ſoft, tough, and infuſible, is burned away, together with a portion of the iron itſelf, while the remainder is left in a much purer ſtate.

Theſe are the facts obſerved at the furnaces. But the obſervations and inquiries of the chemiſt muſt be carried further, in order to determine what it is that iron gains or loſes at the time of its converſion into its various ſtates. It is found that crude iron approaches towards the ſoft ſtate, not only by heating with expoſure to the air, which burns the combuſtible addition, but likewiſe by fuſion, without the free acceſs of air. In this caſe, when the fuſion has been complete, and the cooling gradual, it is found that a black ſubſtance is thrown up to its ſurface, which is more abundant the greyer or blacker the iron; and the ſame black ſubſtance is obſerved to coat the ladles of forged iron, which are uſed to take out the metal, and pour it into moulds for caſting ſhot, and other articles. It appears therefore that the heated iron, like other heated fluids, is capable of holding a larger quantity of matter in ſolution than when cold; and that a portion of this black ſubſtance ſeparates during the cooling, whether by the gradual effect of ſurrounding bodies, or by the contact of the ladle, in the ſame manner as various falls are ſeparated, in part, from water, by a diminution of temperature. From chemical analyſis, as well as from its obvious characters, this black ſubſtance is found to be plumbago, or the material uſed to make pencils, and commonly known by the name of black lead.

The preſence of this black matter is likewiſe exhibited by diſſolving ſteel, or crude iron, in acids, in which plumbago is inſoluble, and therefore remains behind in the form of a powder. Hence likewiſe is deduced the cauſe of the black ſpot which remains upon ſteel, or crude iron, after its ſurface has been corroded by acids; for this ſpot conſiſts of the plumbago which remains after the iron has diſappeared by ſolution.

Solution in the vitriolic or marine acids, not only exhibits the plumbago contained in iron, but likewiſe poſſeſſes the advantage of ſhewing the ſtate of its reduction by the quantity of inflammable air which is diſengaged: for whether this aerial fluid be ſupplied by the phlogiſton of the iron, or from the decompoſed water, it is agreed on all hands that its quantity, in like circumſtances, is proportional to that of the iron which is converted into calx. There are conſiderable differences between the various products of the ſmelting furnace in theſe reſpects; but it is found that the white crude iron affords the leaſt quantity of inflammable air in proportion to its bulk, and leaves a moderate portion of plumbago; the grey crude iron affords more inflammable air, and more plumbago, than the white;

white; and the ſofteſt bar iron affords moſt inflammable air of any, and little or no plumbago. The quantities of inflammable air*, at a medium, by ounce meaſures, were 62, afforded by 100 grains of the white crude iron; 71 by the grey crude iron; and 77 by the malleable iron.

Hence it may be inferred that, in the white crude iron, the proceſſes of reduction and cementation are both carried to a leſs extent than in the grey crude iron, which is produced by means of a ſtronger heat, excited with a larger quantity of fuel: and that the reduction of grey crude iron is ſtill leſs perfect than that of the ſoft bar iron; though this laſt, by the refining in an open veſſel, is ſo far from being more cemented, that it ſcarcely contains any plumbago at all.

It muſt be admitted, however, that the ſolution in acids ſerves only to ſupport theſe general concluſions, in conjunction with the facts obſerved in the dry proceſſes; but cannot accurately ſhew either the quantities of inflammable air or plumbago afforded by the ſeveral kinds of iron. For the plumbago, as it becomes diſengaged, floats on the top of the vitriolic acid; where it gradually diſappears, though inſoluble in that acid. It muſt therefore be taken up by the inflammable air, and it is found that the volume of this air is diminiſhed by the abſorption. Hence there is a double ſource of inaccuracy from the loſs of plumbago, and the contraction of the inflammable air.

On the whole then, ſince iron contains plumbago in a ſtate of combination, of which it may be deprived by heat, with acceſs of vital air, which converts it into the acid called fixed air, as Scheele's experiments ſhew (*ſee* PLUMBAGO); and ſince it recovers the plumbago by cementation with charcoal, there can be no queſtion, but that this ſubſtance is originally afforded by the fuel. It appears alſo that the reduction of the metallic calx takes place firſt at a lower temperature; and that the combination of the baſe of fixed air follows at a greater heat. Whence, in the refining of iron, the plumbago is firſt burned, and the iron remains reduced; and in the cementation of bar iron, the metal is converted into ſteel, with bliſters on its ſurface; which moſt probably ariſe from fixed air formed by the vital air of ſome portions of unreduced calx, uniting with the acidifiable baſe from the charcoal. And, laſtly, as iron holds this acidifiable baſe, or phlogiſticated acid, in ſolution, ſo likewiſe it may not be ſeparable from this metallic ſolvent, without carrying a portion with it; in the ſame manner as ſalts, which cryſtallize in water, always take up part of the ſolvent in the formation of their cryſtals.

It would require many volumes to enumerate the leading uſes of iron. This moſt valuable of metals is applied to ſo many, and ſuch important uſes, that we cannot look round us without ſeeing its effects. When we contemplate the innumerable effects of human induſtry, and aſk ourſelves the ſimple queſtion, could this have been done without iron? there is not a ſingle inſtance which will not immediately ſhew its value. It is indeed difficult to form an idea, how civilized ſociety could exiſt without it.

ISINGLASS. This ſubſtance, though well known in the arts, has been greatly miſtaken, not only with regard to the manner of its fabrication †, but as to the effects it produces. As Mr. Jackſon has given a good account of iſinglaſs, from his own obſervations and experiments, in the Philoſophical Tranſactions for 1772, I ſhall here chiefly follow his authority.

* Acad. Par. 1786, pages 166, 167. The numbers in the text are given as a rough meaſure; for, in fact, there can be no medium.

† It is ſaid to be made in the ſame manner as glue, by Pomet, Neumann, Lewis, and Chaptal.

The principal conſumption of iſinglaſs is in fining liquors of the fermented kind. It appears to do this merely by the mechanical effect of its organization, which forms a kind of ſtrainer, or fine net work, and carries the groſs impurities before it, as it ſubſides. Glue is unfit for this purpoſe, becauſe it wants the peculiar ſtructure. Iſinglaſs itſelf, if converted into glue by boiling, though excellent for the purpoſes of cementing wood and other articles, is no longer uſeful for fining liquors.

Iſinglaſs is made from certain fiſh found in the Danube, and the rivers of Muſcovy. Willoughby and others inform us, that it is made of the ſound of the Beluga; and Neumann, that it is made of the Huſo Germanorum, and other fiſh, which he has frequently ſeen ſold in the public markets of Vienna. Mr. Jackſon remarks that the ſounds of cod, properly prepared, afford this ſubſtance, and that the lakes of America abound with fiſh from which the very fineſt ſort may be obtained.

The ſounds, or air bladders of freſh water fiſh, in general, are preferred for this purpoſe, as being the moſt tranſparent, flexible, delicate ſubſtances. Theſe conſtitute the fineſt ſorts of iſinglaſs; thoſe called book and ordinary ſtaple, are made of the inteſtines, and probably the peritonæum of the fiſh. The Beluga yields the greateſt quantity, as being the largeſt and moſt plentiful fiſh in the Muſcovy rivers; but the ſounds of all freſh-water fiſh yield, more or leſs, fine iſinglaſs, particularly the ſmaller ſorts, found in prodigious quantities in the Caſpian ſea, and ſeveral hundred miles beyond Aſtracan, in the Wolga, Yack, Don, and even as far as Siberia, where it is called *kle* or *kla* by the natives, which implies a glutinous matter; it is the baſis of the Ruſſian glue, which is preferred to all other kinds for its ſtrength.

The ſounds, which yield the finer iſinglaſs, conſiſt of parallel fibres, and are eaſily rent longitudinally; but the ordinary ſorts are found compoſed of double membranes, whoſe fibres croſs each other obliquely, reſembling the coats of a bladder: hence the former are more readily pervaded and divided with ſubacid liquors; but the latter, through a peculiar kind of interwoven texture, are with great difficulty torn aſunder, and long reſiſt the power of the ſame menſtruum; yet, when duly reſolved, are found to act with equal energy in clarifying liquors.

Iſinglaſs receives its different ſhapes in the following manner:

The parts of which it is compoſed, particularly the ſounds, are taken from the fiſh while ſweet and freſh, ſlit open, waſhed from their ſlimy *ſordes*, diveſted of every thin membrane which invelops the ſound, and then expoſed to ſtiffen a little in the air. In this ſtate, they are formed into rolls about the thickneſs of a finger, and in length according to the intended ſize of the ſtaple: a thin membrane is generally ſelected for the centre of the roll, round which the reſt are folded alternately, and about half an inch of each extremity of the roll is turned inwards. The due dimenſions being thus obtained, the two ends of what is called ſhort ſtaple are pinned together with a ſmall wooden peg; the middle of the roll is then preſſed a little downwards, which gives it the reſemblance of a heart, and thus it is laid on boards, or hung up in the air to dry. The ſounds which compoſe the long ſtaple, are larger than the former; but the operator lengthens this ſort at pleaſure, by interfolding the ends of one or more pieces of the ſound with each other. The extremities are faſtened with a peg, like the former; but the middle part of the roll is bent more conſiderably downwards; and in order to preſerve the ſhape of the three obtuſe angles thus formed, a piece of round ſtick, about a quarter of an inch diameter, is faſtened in each angle with

with ſmall wooden pegs, in the ſame manner as the ends. In this ſtate it is permitted to dry long enough to retain its form, when the pegs and ſticks are taken out, and the drying completed: laſtly, the pieces of iſinglaſs are colligated in rows, by running packthread through the peg holes, for convenience of package and exportation.

The membranes of the book ſort, being thick and refractory, will not admit a ſimilar formation with the preceding: the pieces therefore, after their ſides are folded inwardly, are bent in the centre, in ſuch manner that the oppoſite ſides reſemble the cover of a book, from whence its name; a peg being run acroſs the middle, faſtens the ſides together, and thus it is dried like the former. This ſort is interleaved, and the pegs run acroſs the ends, the better to prevent its unfolding.

That called cake iſinglaſs is formed of the bits and fragments of the ſtaple ſorts, put into a flat metalline pan, with a very little water, and heated juſt enough to make the parts cohere like a pancake, when it is dried; but frequently it is overheated, and ſuch pieces, as before obſerved, are uſeleſs in the buſineſs of fining. Experience has taught the conſumers to reject them.

Iſinglaſs is beſt made in the ſummer, as froſt gives it a diſagreeable colour, deprives it of weight, and impairs its gelatinous principles; its faſhionable forms are unneceſſary, and frequently injurious to its native qualities. It is common to find oily putrid matter and *exuviæ* of inſects between the implicated membranes, which through the inattention of the cellar-man often contaminate wines and malt liquors in the act of clarification. Theſe peculiar ſhapes might, probably, be introduced originally with a view to conceal and diſguiſe the real ſubſtance of iſinglaſs, and preſerve the monopoly.

The ſounds of cod and ling bear great analogy with thoſe of the *accipenſer genus* of Linnæus and Artedi, and are in general ſo well known, as to require no particular deſcription. The Newfoundland and Iceland fiſhermen ſplit the fiſh, as ſoon as taken, and throw the back bones, with the ſounds annexed, in a heap; but previous to incipient putrefaction, the ſounds are cut out, waſhed from their ſlimes, and ſalted for uſe. In cutting out the ſounds, the intercoſtal parts are left behind, which are much the beſt: the Iceland fiſhermen are ſo ſenſible of this, that they beat the bone upon a block with a thick ſtick, till the pockets, as they term them, come out eaſily, and thus preſerve the ſound entire. If the ſounds have been cured with ſalt, that muſt be diſſolved by ſteeping them in water, before they are prepared for iſinglaſs; the freſh ſound muſt then be laid upon a block of wood, whoſe ſurface is a little elliptical, to the end of which a ſmall hair bruſh is nailed, and with a ſaw knife the membranes on each ſide of the ſound muſt be ſcraped off. The knife is rubbed upon the bruſh occaſionally, to clear its teeth; the pockets are cut open with ſciſſars, and perfectly cleanſed of the mucous matter with a coarſe cloth: the ſounds are afterwards waſhed a few minutes in lime water, in order to abſorb their oily principle, and laſtly in clear water. They are then laid upon nets to dry in the air; but if intended to reſemble foreign iſinglaſs, the ſounds of cod will only admit of that called book, but thoſe of ling both ſhapes. The thicker the ſounds are, the better the iſinglaſs, colour excepted; but that is of no conſequence to the brewer, who is chief conſumer.

This iſinglaſs reſolves into fining, like the other ſorts, in ſub-acid liquors, as ſtale beer, cyder, old hock, &c. and in equal quantities produces ſimilar effects upon turbid liquors, except that it falls ſpeedier and cloſer to the bottom of the

veſſel, as may be demonſtrated in tall cylindrical glaſſes; but foreign iſinglaſs retains the conſiſtency of fining preferably in warm weather, owing to the great tenacity of its native mucilage.

Vegetable acids appear to be in every reſpect beſt adapted to fining. It has long been a prevalent opinion, that ſturgeon, on account of its cartilaginous nature, would yield great quantities of iſinglaſs; but, on examination, no part of this fiſh, except the inner coat of the ſound, promiſed the leaſt ſucceſs. This being full of rugæ, adheres ſo firmly to the external membrane, which is uſeleſs, that the labour of ſeparating them ſuperſedes the advantage. The inteſtines, however, which in the larger fiſh extend ſeveral yards in length, being cleanſed from their mucus, and dried, were found ſurpriſingly ſtrong and elaſtic, reſembling cords made with the inteſtines of other animals, commonly called catgut, and, from ſome trials, promiſed ſuperior advantages, when applied to mechanic operations.

IVORY. The tuſk or tooth of defence of the male elephant. It is an intermediate ſubſtance, between bone and horn, not capable of being ſoftened by fire, nor altogether ſo hard and brittle as bone. Sometimes it grows to an enormous ſize, ſo as to weigh near two hundred pounds.

The entire tooth is of a yelloviſh, browniſh, and ſometimes a dark brown colour on the outſide, internally white, hollow towards the root, and ſo far as was inſerted into the jaw of a blackiſh brown colour. The fineſt, whiteſt, ſmootheſt, and moſt compact ivory comes from the iſland of Ceylon. The grand conſumption of this commodity is for making ornamental utenſils, mathematical inſtruments, caſes, boxes, balls, combs, dice, and an infinity of toys. There are many exquiſite pieces of workmanſhip, as medals and chains, curious ſpinning-wheels, &c. made entirely out of one tooth. In his Pruſſian majeſty's collection, there is a chair, a pair of cheſs tables, and ſundry other curioſities of ivory. The workmen have methods alſo of tingeing it of a variety of colours.

From four drams of raſped ivory treated with rectified ſpirit, Neumann obtained three grains of extract, in taſte ſomewhat rancid, but of no ſmell: the remainder inclined a little to reddiſh. On boiling four drams in pure diſtilled water, and inſpiſſating the decoction, he obtained ſix drams of jelly, or a gelatinous extract; but as the dried reſiduum weighed three drams and a ſcruple, it is plain that in the ſix drams of jelly there were only two ſcruples afforded by the ivory, all the reſt being water; and hence we learn what a large proportion of water is retained in jellies. The jelly taſted manifeſtly ſaline; the remaining ivory proved conſiderably brittle and earthy.

Diluted vitriolic acid totally diſſolves ivory, and affords a precipitate of ſelenite. Phoſphoric acid is diſengaged. The nitrous and marine acids likewiſe decompoſe ivory. Pure alkalis combine with its oily part, and deſtroy its texture. The products of deſtructive diſtillation are nearly the ſame as obtained from other animal ſubſtances, viz. water impregnated with volatile alkali, ſome concrete alkali, oil, and a reſidual coal, which by incineration becomes white, and conſiſts of phoſphorated lime. The coal of ivory is uſed in the arts under the denomination of ivory black. Particular veſſels are uſed in the manufactory of this pigment, for the purpoſe of rendering it perfectly black.

Some travellers ſpeak of the tooth of the ſea-horſe as an excellent ivory; but it is too hard to be ſawed or wrought like ivory. It is uſed for making artificial teeth.

J

J A C J A L

JACINTA LA BELLA. The jacinta la bella of the Italians is a garnet of a yellowiſh hue: but when it is more of a reddiſh colour, it is then called vermeille by the French.

JACK, BLACK. The miners' term for blende, or mock lead. See BLENDE.

JADE. *Lapis nephriticus, jaſpachates.*

The true lapis nephriticus ſeems to belong to the ſiliceous order; as it gives fire with ſteel, and is ſemi-pellucid like flint; it does not harden in fire, but melts by the ſolar heat in the focus of a burning lens, into a tranſparent green glaſs with ſome bubbles. That called by the name of *circumciſion ſtone*, which comes from the Amazon river, melts eaſier, in the ſame ſolar fire, into a brown opaque glaſs, which is far leſs hard than the ſtone itſelf.

This ſtone is ſuperior in hardneſs to quartz, though, from its unctuoſity to the touch, one would ſuſpect it to contain a large portion of argillaceous earth, or rather of magneſian earth, as Mr. Kirwan ſeems to ſuſpect.

Its ſpecific gravity is from 2.970 to 3.389. It is of a granular texture, of a greaſy look, and exceedingly hard; is ſcarcely ſoluble in acids, at leaſt without particular management, and is infuſible in the fire. M. Sauſſure ſeems to have extracted iron from it.

It is ſometimes of a whitiſh milky colour, from China; but moſtly of a greeniſh, or deep green colour, from America, or of a grey, yellowiſh and olive colour. The jade is vulgarly denominated lapis nephriticus, from being ſuppoſed to cure nephritic pains by external application to the loins.

The ſemi-tranſparency, hardneſs, and ſpecific gravity are the characters by which the lapis nephriticus may be diſtinguiſhed from other ſtones.

JALAP is the root of a ſpecies of convolvulus, with leaves like thoſe of ivy, but not ſo thick, and beautiful red flowers, which have this remarkable property, that they open in the night, and ſhut again on the leaſt appearance of the ſun; whence the plant is called by the French *Belle de nuit*, the beauty or fair one of the night: in rainy or cloudy days the flowers open a little, but fall off the ſooner, as if day-light was injurious to them. The jalap plant is a native of the province Chalapa or Xalapa, in New Spain, from whence its name is derived, and written, according to the pronunciation of different languages, *Jalapa* or *Jalapium*, *Gialappa*, *Chalapa*, *Xalapa*, *Zalapa*, &c. The roots raiſed in Europe have been found much weaker than the American.

Jalap is brought over in thin ſlices; of which the beſt are compact and hard, ſo as not to be broken by the fingers; ponderous, of a dark brown colour, of a gloſſy reſinous appearance, or at leaſt furniſhed with reſinous ſtreaks and circles; eaſily inflammable, of no ſmell, or a faint unpleaſant one, and of a ſlight acrid taſte: the fine duſt which flies off in powdering them, provokes ſneezing. Thoſe which are thoroughly reſinous, are not liable to be worm-eaten, the worms preying chiefly upon the gummy or mucilaginous parts, and not touching the reſin, or at leaſt not till theſe are conſumed: hence we may ſuppoſe the worm-eaten roots to have been originally of a bad kind, produced in moiſt ſoils or rainy ſeaſons, &c. and hence the worm-eaten may be employed for making extracts equally with any other, the reſin being equal in goodneſs, though leſs in quantity.

From ſixteen ounces of good jalap-root, Neumann obtained, by ſpirit of wine, five ounces and four ſcruples of reſinous extract, and afterwards by water, two ounces and a half of a gummy one: on applying water at firſt, he gained four ounces and a half of gummy extract, together with ſix drams of a reſinous matter, which fell to the bottom in evaporating the decoction; the remainder yielded, with ſpirit, three ounces of reſin: the indiſſoluble part amounted in the firſt caſe to eight ounces three drams, in the latter to ſeven ounces ſix drams. By precipitating a ſpirituous tincture of the root with water, he gained, from a pound, four ounces of pure reſin.

The inferior ſorts of jalap yield leſs reſinous and more gummy extract; ſuch muſt have been that employed by Boulduc, who obtained, from ſixteen ounces, only two ounces five drams and a ſcruple of reſinous extract; but upwards of eight ounces and a half of a gummy one.

It has been remarked, that jalap poſſeſſes a notable degree of fermentative power; exciting this action in groſs, ſweet, vegetable juices, ſuch as melaſſes, and at the ſame time impregnating them with its purgative quality. I am informed however, that this is by no means the caſe, but that it is uſed to check the rapid progreſs of fermentation in the manufacture of melaſſes' ſpirits, for which purpoſe it is ſtrewed over the ſurface of the liquor. It is a late diſcovery, that common reſin will do as well. This effect requires explanation. Perhaps the reſin may combine with part of the ardent ſpirit, at the inſtant of its extrication. If this be true, it ſeems likely that ſo much of the ſpirit may be prevented from riſing in diſtillation, and more loſs may be ſuſtained by this practice than might have followed from the activity of the fermentation.

JAPAN EARTH. *Catechu*, ſo called from its having been long ſuppoſed by the Europeans to be an earthy ſubſtance found in Japan, is neither one nor the other. It belongs to the claſs of gummy-reſins; being ſuch a combination of gummy and reſinous matter, as the extracts made from vegetables by water. In effect, it is no other than a preparation of this kind, obtained by inſpiſſating a watery decoction, or the expreſſed juice of the fruit of a certain palm-tree, growing plentifully on the ſea-coaſts in Coromandel, Cambia, Racaim, Manora, Daman, and ſeveral other parts of the Eaſt Indies. The fruit, held there as a delicacy, is called *faufe*, its kernel *areca*, and the leaves of the tree *betel*; hence the names of the plant, *Palma faufelifela*, *arecifera*, *&c.*

The beſt Japan earth is that prepared by expreſſion, but the greater part of what is brought to us is a true watery extract. There are conſiderable differences in the product, according to the manner in which the proceſs has been managed, and the degree of maturity or perfection of the fruit itſelf; that lime-water, gum-arabic, liquorice, vitriol, or other like ſubſtances are added, is a groundleſs conjecture. Some ſorts are of a pale reddiſh-brown colour, others of a dark blackiſh-brown, or quite black like bitumen; ſome are ponderous, and others light; ſome compact, and others porous; ſome more and others leſs aſtringent. The beſt ſort is of a dark reddiſh-brown, dry, heavy, hard, compact and gloſſy; chewed, it diſcovers at firſt a bitteriſh ſtyptic taſte, which is followed by an agreeable ſweetneſs.

Japan earth, when pure, is almoſt totally diſſolved; its aſtringency at leaſt is totally extracted both by water and ſpirit. Four ounces of the beſt Neumann could procure, yielded with water three ounces and ſix drams of ſolid extract; after which, rectified ſpirit took up no more than twelve grains; the indiſſoluble part conſiſted chiefly of ſand, woody and other foreign matters. Four ounces

of the ſame Japan earth, treated firſt with rectified ſpirit, gave juſt three ounces of reſinous extract; the reſiduum ſtill yielded with water five drams two ſcruples and eight drams of a gummy one. Another parcel yielded, on the ſame quantity, two drams more of ſpirituous than of watery extract; but all the ſorts agree in the material points, namely, 1. That the ſpirituous tincture is of a redder colour, brighter, clearer, and more fluid than the watery; the latter appearing browniſh, quite thick, and at laſt curdly. 2. That the ſpirituous extract inſpiſſated, proves ſtronger, more aſtringent, and more diſagreeable than the watery; the latter poſſeſſing the agreeable ſweetneſs of the Japan earth itſelf, improved rather than injured. 3. That the extracts made by water after ſpirit, and by ſpirit after water, have no remarkable taſte.

Hence, when a ſtrong aſtringent is required, whether for external or internal purpoſes, we are directed to the ſpirituous tincture and extract; and for a milder and more grateful corroborant, to the watery extract. A little of this laſt taken into the mouth at bed-time, and ſuffered ſlowly to diſſolve, is ſaid to be remarkably ſerviceable in diſorders of the throat.

JARGON. A hard gem brought from the Eaſt Indies in the form of thin plates, which appear to be ſplit from pebbles. They are of different colours, white, black, yellow, and brown, about as hard as the ſapphire. As they have a great reſemblance to the diamond, they are ſubſtituted inſtead of it in jeweller's work, ſometimes fraudulently. It is probable that the great ſpecific gravity of this ſtone, which in ſome ſpecimens exceeds that of the ponderous ſpar, may be attended with an extraordinary degree of refractive power, on which the brilliancy of precious ſtones depends. See DIAMOND.

Romare ſays, that the jargon is found in Braſil, but Romé de l'Iſle informs us that it comes from Ceylon, and that its form conſiſts of two tetrahedal pyramids of equal ſides, ſeparated by a ſhort priſm. M. D'Arcet expoſed it to a violent heat in a porcelain teſt. Its ſurface was a little vitrified, and it ſtuck to the veſſel; whence it appears that the jargon has not the leaſt affinity to the diamond, which is deſtructible by fire.

M. Klaproth analyſed the jargon of Ceylon, and found that more than two thirds of its weight conſiſted of an earth ſoluble in acids, but different in its properties from any other of the earths. See EARTH OF THE JARGON.

JASPACHATES. See JADE.

JASPER. *Jaſpis.* (The Diaſpro of the Italians.)

All opaque flints are called by this name, whoſe texture reſembles dry clay, and which have no other known quality, whereby they may be diſtinguiſhed from other flints, except that they may be more eaſily melted in the fire; and this quality, perhaps, may proceed from the mixture of iron. It often breaks with conchoidal ſurfaces; is capable of a fine poliſh; its colour is generally reddiſh or green, or ſtriped; but it is alſo found blue, grey, or whitiſh; its ſpecific gravity is from 2.68 to 2.778 or more, when it contains more iron.

Jaſper is infuſible alone with the blow pipe; with the mineral alkali it is only partially ſoluble, ſeparating itſelf with efferveſcence, into ſmall particles; but it melts with *borax* or *microcoſmic ſalt*, without any efferveſcence.

According to Bergman, in his Sciagraphia, it is compoſed of *ſiliceous earth*, united to an argill very full of iron. The mineral acids have no action upon jaſper in a ſhort time, but at the end of ſome months it is found corroded, if immerſed in them. A ſmall piece of green jaſper having been treated with the vitriolic

vitriolic acid, gave ſome cryſtals of alum, and ſome martial vitriol, which demonſtrates that argill and iron enter into its compoſition.

M. Daubenton mentions 15 varieties of jaſper. 1. The *green*, from Bohemia, Sileſia, Siberia, and the ſhores of the Caſpian ſea. This ſeems to be the *pavonium* of Aldrovandus. 2. The *red*, or the *diaſpro roſſo* of the Italians, which is not ſo common, nor in ſuch great maſſes, as the green. 3. The *yellow*, from Freyberg and Rochtliz; it is ſometimes of a citron colour, and looks as if compoſed of ſilky filaments. This is called the *ſilk jaſper*. 4. *Brown*, from Dalecarlia, in Finland and Sweden. 5. The *violet*, from Siberia. 6. The *black*, from Sweden, Saxony, and Finland. This is the *paragone antico* of the Italians. 7. The *blueiſh grey*, which is very rare. 8. The *milky white*, of which Pliny ſpeaks; it is found in Dalecarlia. 9. The *variegated* with *green*, *red*, and *yellow* clouds. 10. The *blood ſtone*, which is green with red ſpecks, from Egypt, and was ſuppoſed to ſtop the blood. 11. The *veined*, with various colours. When theſe veins have the reſemblance of letters, it is then called *jaſpe grammatique* by the French. Some of this kind are found near Rochelle, in France, and called *polygrammatiques* by the curious in theſe trifling accidental qualities. 12. That which has various coloured zones. 13. That called *fiorito* by the Italians, which has its various colours promiſcuouſly, without any order. 14. When the jaſper has a great number of colours together, it is then (very improperly) called univerſal. 15. Laſtly, when the jaſper is found to contain ſome portions of agate, it is then called *agatized jaſper*.

JELLY. An animal ſubſtance ſoluble in water whether hot or cold. Its principal properties are detailed under the article JELLY. It is uſed either as food, or as a cement in the arts under the name of glue. Meſſrs. Parmentier and Pelletier made ſome judicious experiments upon glue made from bones by M. Grenet, of which an account is inſerted in the 13th volume of the Annales de Chimie, p. 192. Six pounds of raſpings of bone from the button-mould makers were put into a copper boiler with twenty-four pints of water, and in that ſtate left to ſoak for two days without heat. At this period the veſſel was placed on a fire, and after the expiration of one hour the fluid was in a ſtate of ebullition, which was continued for nine hours. The materials were then left to ſubſide for a night. The ſupernatant fluid, or glue, was by this means rendered clear. It was drawn off with a ſyphon. The quantity was fourteen pints, and two pints more were obtained by preſſure from the dregs. This clear fluid was afterwards concentrated by farther evaporation, then ſuffered to cool for half an hour, and poured into wooden moulds. In the courſe of the day it had acquired the conſiſtence of a firm jelly, which was cut into cakes, and dried upon a net. Fourteen days were requiſite for this purpoſe, in the ſhade, the weather being rainy and damp. The quantity of glue was fifteen ounces and four drams, with the addition of four drams more obtained by preſſure from the dregs. The dried reſidue weighed four pounds three ounces, and the loſs was thirteen ounces. The glue was therefore one ſixth of the weight of the bones.

Ivory raſpings treated in the ſame manner, afforded upwards of one fifth part of their weight of glue.

The dark colour of glue was found to ariſe from the action of the heat in the laſt evaporation. Theſe intelligent chemiſts, adverting to the fact, that iſinglaſs is rendered clear and white by fumigation with ſulphur; but at the ſame time reflecting, that glue not being compoſed of thin fibres, was incapable of undergoing

going this proceſs, as to its interior part, determined to try the ſolution of ſulphureous or volatile vitriolic acid. They prepared a pale jelly by a ſhort ebullition of raſpings of bones in the ſmalleſt poſſible quantity of water. To this they added a little water charged with ſulphureous acid, and mixed the fluids well together. The experiment ſucceeded. They propoſed as a preliminary operation to bleach the raſpings by the ſame means, where a pale-coloured glue is required.

Theſe commiſſaries found, that the glue manufactured by M. Grenet was equal in quality to the beſt made in England, or elſewhere. They could not make glue from horn.

JESUITS BARK. See PERUVIAN BARK.

JET. *Gagas*, *Succinum nigrum*. Lat. *Jet*, or *Jayet*. French.

The *jet*, the *lapis obſidianus*, and the *foſſil wood*, penetrated by mineral inflammable matter, are often confounded together, on account of their black gloſſy colour. But the lapis obſidianus is a volcanic glaſs, and jet is a compact bitumen. Jet is much harder than aſphaltum, always black, ſuſceptible of a good poliſh, and gloſſy in its fracture, which is conchoidal; its ſpecific gravity is 1.744; it melts in a moderately ſtrong heat, with a diſagreeable ſmell; when burnt, it leaves a grey earthy ochrous reſiduum; it is inſoluble in ſpirit of wine.

It is found in *England*, *Scotland*, *France*, *Italy*, *Germany*, *&c.* Wallerius, Bomare, and others aſſert, that it floats on water; a circumſtance which, if true, muſt indicate a ſpecific gravity not greatly exceeding the half of the above, which is from Kirwan.

The uſe of this foſſil conſiſts in the manufacture of ſmall toys. It is alſo ſaid to be an ingredient in varniſhes.

JEWS PITCH. See ASPHALTUM.

JUICES OF PLANTS. The juices of ſeveral plants are expreſſed to obtain their eſſential ſalts, and for ſeveral medicinal purpoſes, with intention either to be uſed without further preparation, or to be made into ſyrups and extracts.

The general method of extracting theſe juices is, by pounding the plant in a marble mortar, and then by putting it into a preſs. Thus is obtained a muddy and green liquor, which generally requires to be clarified, as we ſhall ſoon obſerve.

The juices of all plants are not extracted with equal eaſe. Some plants, even when freſh, contain ſo little juice, that water muſt be added while they are pounded, otherwiſe ſcarcely any juice would be obtained by expreſſion. Other plants, which contain a conſiderable quantity of juice, furniſh by expreſſion but a ſmall quantity of it, becauſe they contain alſo much mucilage; which renders the juice ſo viſcid that it cannot flow. Water muſt alſo be added to theſe plants to obtain their juice.

The juices thus obtained from vegetables by a mechanical method, are not, properly ſpeaking, one of their principles, but rather a collection of all the proximate principles of plants which are ſoluble in water; ſuch as the ſaponaceous extractive matter, the mucilage, the odoriferous principle, all the ſaline and ſaccharine ſubſtances; all which are diſſolved in the water of the vegetation of the plants. Beſides all theſe matters, the juice contains ſome part of the reſinous ſubſtance, and the green colouring matter. Theſe two latter ſubſtances, not being ſoluble in water, are only interpoſed between the parts of the other principles which are diſſolved in the juice, and conſequently diſturb its tranſparency.

They nevertheleſs adhere together in a certain degree, and ſo ſtrongly in moſt juices, that they cannot be ſeparated by filtration alone.

When therefore theſe juices are to be clarified, ſome previous preparations muſt be uſed by which the filtration may be facilitated. Juices which are acid, and not very mucilaginous, are ſpontaneouſly clarified by reſt and gentle heat. The juices of moſt anti ſcorbutic plants abounding in ſaline volatile principles, may be diſpoſed to filtration merely by immerſion in boiling water; and as they may be contained in cloſed bottles while they are thus heated in a water bath, their ſaline volatile part, in which their medicinal qualities chiefly conſiſt, may thus be preſerved. Fermentation is alſo an effectual method of clarifying juices which are ſuſceptible of it; for all liquors which have fermented, clarify ſpontaneouſly after fermentation. But this method is not uſed to clarify juices, becauſe many of them are ſuſceptible of only an imperfect fermentation, and becauſe the qualities of moſt of them are hindered by that proceſs.

The method of clarification moſt generally uſed, and indiſpenſably neceſſary for thoſe juices which contain much mucilage, is by boiling with the white of an egg. This matter, which has the property of coagulating in boiling water, and of uniting with mucilage, does accordingly, when added to the juice of plants, unite with and coagulate their mucilage, and ſeparates it from the juice in form of ſcum, together with the greateſt part of the reſinous and earthy matters which diſturb its tranſparency. And as any of theſe reſinous matters which may remain in the liquor, after this boiling with the white of eggs, are no longer retained by the mucilage, they may eaſily be ſeparated by filtration. See FILTRATION.

The juices, eſpecially before they are clarified, contain almoſt all the ſame principles as the plant itſelf, becauſe, in the operation by which they are extracted, no decompoſition happens, but every thing remains, as to its nature, in the ſame ſtate as in the plant. The principles contained in the juice are only ſeparated from the groſſer, oily, earthy, and reſinous parts, which compoſe the ſolid matter that remains under the preſs. Theſe juices, when well prepared, have therefore exactly the ſame medicinal qualities as the plants from which they are obtained. They muſt evidently differ from each other, as to the nature and proportions of the principles with which they are impregnated, as much as the plants from which they are extracted differ from each other in thoſe reſpects.

K

KAL KAL

KALI is a maritime plant, from the aſhes of which a conſiderable quantity of mineral fixed alkali is obtained by lixiviation. See ALKALI (FIXED MINERAL). Henckel informs us, that by boiling the plant in water, and by evaporating the decoction, he obtained a conſiderable quantity of ſea ſalt.

KANEL COAL. See CANNEL COAL.

KAOLIN. The Chineſe name of an earth uſed as one of the two ingredients of the oriental porcelain. Some of this earth was brought from China, and examined by M. Reaumur. He found that it was infuſible, and ſuppoſed it to be a talcy earth; but Macquer ſuppoſes it to contain clay, becauſe it forms a tenacious paſte with the other ingredient called petuntſe, which has no tenacity. Bomare found, that it was a compound of clay, or calcareous earth, mica, and ſmall quartz cryſtals. He ſays that he has found a ſimilar earth upon a ſtratum of granite, and conjectures that it may be a decompoſed granite.

As porcelain is now manufactured in various parts of Europe, ſome mineralogiſts have applied the term kaolin to the porcelain clay.

KARABE, or CARABE. See AMBER.

KARAT. The fineneſs of gold is commonly noted by karats. Pure gold being conſidered to be divided into twenty-four equal parts, or karats; it is then ſaid to be twenty-four karats fine. If the quantity of pure gold in any maſs be leſs than this, that quantity only is noted in expreſſing the fineneſs. Thus, for example, if two parts out of the twenty-four be copper or other baſe metal, the gold is ſaid to be twenty-two karats fine. This is the ſtandard of Britiſh coin. See ASSAY.

The karat is a real weight uſed by jewellers, divided by us into four grains: but theſe grains are leſs than the grains of troy-weight; four grains troy being equal to five of theſe ſub-diviſions of the karat, according to David Jefferys. See DIAMOND.

KEDRIA TERRESTRIS. Barbadoes tar; a mineral oil reſembling ſoft pitch. It is viſcid, and of a brown black, or reddiſh black colour, eaſily fuſible, and burning with much ſmoke and ſoot. Ardent ſpirit does not diſſolve it, but mineral alkali extracts a portion of the acid of amber.

KEFFEKIL. A ſtone of a white or yellow colour, ſoapy feel, and moderate hardneſs which increaſes in the fire. It is the ſubſtance of which the large Turkey pipes are made. It is found in Crim Tartary, in Canada, in Flanders, and elſewhere. The Tartars uſe it inſtead of ſoap, as do likewiſe the country people in the barony of Hierges, in Auſtrian Flanders. Wiegleb found it to conſiſt of equal parts of magneſia and ſilex, whence it ſeems to operate as a fullers-earth. See EARTH (FULLERS).

KERMES (*coccus ilicis, Lin.*) is an inſect found in many parts of Aſia, and the ſouth of Europe. It was known to the ancients by the name of *coccum ſcarlatinum, coccus baptricus, coccus infectorius, granum tinctorium.* That which came from Galatia and Armenia was preferred; but at preſent it is gathered chiefly in Languedoc, Spain, and Portugal.

The kermes lives on a ſmall kind of oak (*quercus coccifera, Lin.*). The females grow big, and at length remain motionleſs; when they are nearly the ſize and ſhape of a pea, and of a reddiſh brown colour. On account of their figure, they were a long time taken for the ſeeds of the tree on which they live; whence they were called *grains of kermes.* They alſo bore the name of vermilion.

The firſt who has ſpoken of them with any accuracy is Peter de Quiqueran, biſhop of Senez, who mentions them in his book, *De Laudibus Provinciæ*, 1550.

The hiſtory of this inſect may be ſeen in a memoir of Niſſole, *Acad. des Sciences*, 1714, and more particularly in Reaumur's *Mémoires pour ſervir à l'Hiſtoire des Inſectes*, tom. iv.

Kermes has been ſuppoſed to have derived its name from an Arabic word, ſignifying a little worm, *vermiculus*; whence the name of vermilion, which has alſo been given it. Aſtruc derives the name from two Celtic words, one of which ſignifies *an oak*, the other *an acorn**.

The kermes fixes itſelf to the back of the ſhrub on which it is found, by means of a cottony down which it is capable of furniſhing. Mr. Chaptal has obſerved, that this down, like that of all the inſects of this kind, has many characteriſtics of the caoutchouc; it is inſoluble in alcohol, melts at the heat of boiling water, and burns with a flame on the coals. That learned chemiſt gave Bartholate the following deſcription of the mode of gathering it in Languedoc:

About the middle of May they begin to gather kermes, which is then arrived at its ordinary ſize, and in colour and ſhape reſembles a ſmall ſloe (prunelle). This harveſt generally continues to the middle of June, and ſometimes longer, if the great heats be retarded, or no violent rains fall; for one heavy ſtorm of rain is ſufficient to put an end to the gathering for that year.

In this occupation women are generally employed. They ſet out early in the morning, with a lanthern, and a glazed earthen pot, to pick off the kermes from the branches with their fingers before day. This time is the moſt favourable: 1ſt. Becauſe the leaves, which are prickly, are then leſs troubleſome, being ſoftened by the morning dew. 2dly. Becauſe the kermes weighs more; whether becauſe it is not dried by the ſun, or becauſe it has parted with fewer of its young, which are hatched by the warmth. Some, however, are bold enough to gather it in the day-time, but this is rarely done.

A ſingle perſon may gather one or two pounds a-day.

At the beginning of the harveſt, the kermes weighs more, but fetches a leſs price than at the end, when it is drier and lighter.

The price of freſh kermes varies alſo according to the demand for it, and its ſcarcity. It commonly ſells for fifteen or twenty ſous a pound, at the beginning of the gathering, and for thirty or forty towards the end.

The buyers are obliged as ſoon as poſſible to ſtop the progreſs of the eggs, in order to prevent the young contained in the ſhell from getting out. This ſhell is nothing but the body of the mother, diſtended by the growth of the eggs. The female has no wings: it ſettles itſelf on a leaf, where it fixes: the male comes to fecundate it: and it afterwards increaſes in ſize merely from the growth of the eggs. To kill the young contained in theſe, the kermes is ſteeped ten or twelve hours in vinegar, which requires leſs time, as half an hour is ſufficient. It is afterwards dried on linen cloths. This operation gives it a colour like that of red wine.

If the living inſect be bruiſed, it gives out a red colour. Its ſmell is ſomewhat pleaſant; its taſte a little bitter, rough, and pungent. When dry it imparts this ſmell and taſte to water, and alſo to alcohol, to both which it gives a deep red colour. This colour is retained by the extracts made from theſe infuſions.

To dye ſpun worſted with kermes, it is firſt boiled half an hour in water with bran; then two hours, in a freſh bath, with one-fifth of Roman alum, and one-tenth of tartar, to which *four water* is commonly added; after which it is taken out, tied up in a linen bag, and carried to a cool place, where it is

* Mémoire pour ſervir à l'Hiſtoire Naturelle de Languedoc.

left

leſt ſome days. To obtain a full colour, as much kermes as equals three-fourths, or even the whole of the weight of the wool, is put into a warm bath, and the wool is put in at the firſt boiling. As cloth is more denſe than wool, either ſpun or in the fleece, it requires one fourth leſs of the ſalts in the boiling, and of kermes in the bath. Leſs proportions of kermes will produce lighter and paler colours. If we want a ſucceſſion of ſhades, we muſt, as uſual, begin with the deepeſt.

Hellot directs a ſmall handful of cot or refuſe wool to be thrown into the boiler in which the kermes is, and to let it boil a moment before the wool to be dyed is put in. This will abſorb a kind of black dregs, and the wool afterwards dipped will take a better colour. Before the wool that is juſt dyed is taken to the river, it may be dipped in a bath of water a little warm, in which a ſmall quantity of ſoap has been diſſolved. In this way the colour will acquire more brightneſs, though it will be rendered a little roſy, that is, will have a crimſon caſt.

By uſing kermes and tartar, without alum, and with as much ſolution of tin as is required for a ſcarlet with cochineal, Hellot obtained a very lively cinnamon colour in a ſingle bath. Cloth ſteeped in a ſolution of ſulphat of potaſh, took with kermes a pretty fine and permanent agate gray: in a ſolution of ſulphat of iron and tartar, a fine gray: in a ſolution of tartar and ſulphat of copper, an orange colour: and the ſame with nitrat of copper. Solution of biſmuth added drop by drop to a kermes bath, produced a violet. All acids convert it to a cinnamon colour, which inclines more or leſs to red, according as the acids are weak, and their quantity ſmall. Alkalis render its colour dull and roſy.

The colour that kermes imparts to wool, has much leſs bloom than the ſcarlet made with cochineal; whence the latter has generally been preferred, ſince the art of heightening its colour by means of ſolution of tin has been known. Berthollet.

KERMES MINERAL. See ANTIMONY.

KILLAS. This ſtone is chiefly found in Cornwall; its colour is pale gray or greeniſh gray; its texture either lamellar or coarſely granular: the lamellar is ſofter and leſs martial than the roof ſhiſtus: its ſpecific gravity from 2.63 to 2.666.

Kirwan found an hundred grains of the lamellar ſort to contain about 60 of ſilex, 25 of argill, 9 of magneſia, and 6 of iron. The greeniſh ſort contains more iron, and gives a greeniſh colour to the nitrous acid.

KINGDOMS. Naturaliſts and chemiſts divide all natural bodies into three great claſſes, called kingdoms, namely, the mineral, the vegetable, and the animal kingdoms. The utility of theſe diviſions appears to be in a great meaſure confined to the natural hiſtory of the various ſubjects examined by the chemiſt. The diſtinctive criterions of their reſpective principles are difficult, and perhaps impoſſible to be aſcertained, excepting in bodies of no great ſimplicity; for none of the principles of organized bodies exhibit their peculiar characters when reſolved by putrefaction or otherwiſe into their ſimpleſt parts. See ANIMAL KINGDOM, VEGETABLE KINGDOM, MINERAL KINGDOM.

KOLMORD MARBLE. A white calcareous ſtone of a ſcaly texture, interſperſed with ſpots of ſteatites, or ſoap rock, either green or black.

KUPFER NICKEL. See NICKEL.

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LABDANUM. A reſin of a ſpecies of ciſtus in Candia, of a blackiſh colour. The country people collect it by means of a ſtaff, at the end of which are faſtened many leather thongs, which they gently ſtrike on the trees. They form it into cylindrical pieces, which are called labdanum in tortis. It is greatly adulterated by the addition of black ſand, and is uſed as an aſtringent.

LABORATORY. A place properly fitted up for the performance of chemical operations. The ſeveral laboratories intended for the preparation of articles of the materia medica, or the arts, in the large way, have their reſpective accommodations and contrivances, the deſcription of which would occupy ſeveral volumes. The philoſophical chemiſt, whoſe operations afford products chiefly of value for the reſults they exhibit, naturally endeavours, as well for the advantage of time, as expence, to perform all his operations on as ſmall a ſcale as poſſible. It was once thought to be indiſpenſably neceſſary that a philoſophical chemiſt ſhould be provided with a regular laboratory, or room fitted up with furnaces and other apparatus, on a conſiderably extenſive ſcale. This is no doubt of great utility and advantage; but the reſearches of Bergman, Morveau, and other eminent chemiſts, have ſhewn, that much, if not moſt of the chemical operations may be performed with the blow-pipe, or by very ſmall glaſs veſſels, and a ſpirit lamp, with greater ſpeed, perſpicuity, facility, and cheapneſs, than where larger quantities of the materials are uſed. But as the proportional quantities of products, and the indications afforded by experiment for conducting manufacturing proceſſes, are more accurately deduced from conſiderable quantities, I ſhall in this article give the excellent ſketch of a laboratory, as I find it in Macquer's Dictionary.

As chemiſtry is a ſcience founded entirely on experiment, we cannot hope to underſtand it well, without making ſuch experiments as verify moſt of the known fundamental operations, and alſo ſuch as reaſoning, analogy, and the ſpirit of inquiry, never fail to ſuggeſt to thoſe whoſe taſte and ſuitable talents lead them to this eſſential part of experimental philoſophy. Beſides, when a perſon himſelf obſerves, and operates, he muſt perceive, even in the moſt common operations, a great variety of ſmall facts, which muſt neceſſarily be known, but which are not mentioned either in books or in memoirs, becauſe they are too numerous, and would appear too minute. Laſtly, how many qualities are in the ſeveral agents, of which no juſt notion can be given by writing, and which are perfectly well known as ſoon as they have been once made to ſtrike our ſenſes.

A chemical laboratory neceſſarily occaſions certain expences, but not ſo much as is generally believed, when the operator knows how to manage his utenſils, and to employ only the proper quantity of the ſeveral ſubſtances upon which he operates; and laſtly, when he chooſes the leaſt expenſive methods of attaining his purpoſes.

Many people think, that a laboratory level with the ground is moſt convenient, for the ſake of water, pounding, waſhing, &c. It certainly has theſe advantages; but it is alſo ſubject to very great inconvenience from moiſture.

Conſtant moiſture, though not very conſiderable and ſenſible in many reſpects, is a very great inconvenience in a chemical laboratory. In ſuch a place, moſt ſaline matters become moiſt in time, and the inſcriptions fall off, or are effaced; the bellows rot; the metals ruſt; the furnaces moulder, and every thing almoſt ſpoils. A laboratory therefore is more advantageouſly placed above than below the ground, that it may be as dry as poſſible. The air muſt have free acceſs to it; and it muſt even be ſo conſtructed, that, by means of two or more oppoſite openings, a current of air may be admitted to carry off any noxious vapours or duſt.

In the laboratory a chimney ought to be conſtructed, ſo high that a perſon may eaſily ſtand under it, and as extenſive as is poſſible; that is, from one wall to another. The tube of this chimney ought to be as high as is poſſible, and ſufficiently contracted to make a good draught. As charcoal only is burnt under this chimney, no ſoot is collected in it; and therefore it need not be ſo wide as to allow a chimney-ſweeper to paſs up into it.

Under this chimney may be conſtructed ſome brick furnaces, particularly a melting furnace, a furnace for diſtilling with an alembic, and one or two ovens like thoſe in kitchens. The reſt of the ſpace ought to be filled up with ſtands of different heights, from a foot to a foot and a half, on which portable furnaces of all kinds are to be placed. Theſe furnaces are the moſt convenient, from the facility of diſpoſing them at pleaſure; and they are the only furnaces which are neceſſary in a ſmall laboratory. A double bellows of moderate ſize muſt alſo be placed as commodiouſly under the chimney, or as near as the place will allow. Theſe bellows are ſometimes mounted in a portable frame; which is ſufficiently convenient when the bellows is not more than eighteen or twenty inches. Theſe bellows ought to have a pipe directed towards the hearth where the forge is to be placed.

The neceſſary furnaces are, the ſimple furnace, for diſtilling with a copper alembic; a lamp furnace; two reverberatory furnaces, of different ſizes, for diſtilling with retorts; an air or melting furnace, an eſſay furnace, and a forge furnace.

Under the chimney, at a convenient height, muſt be a row of hooks driven into the back and ſide walls; upon which are to be hung ſmall ſhovels; iron pans; tongs; ſtraight, crooked, and circular pincers; pokers; iron rods, and other utenſils for diſpoſing the fuel and managing the crucibles.

To the walls of the laboratory ought to be faſtened ſhelves of different breadths and heights; or theſe ſhelves may be ſuſpended by hooks. The ſhelves are to contain glaſs veſſels, and the products of operations, and ought to be in as great a number as is poſſible. In a laboratory where many experiments are made, one cannot have too many ſhelves.

The moſt convenient place for a ſtone or leaden fountain to contain water is a corner of the laboratory, and under it a ciſtern ought to be placed with a pipe, by which the water poured into it may diſcharge itſelf. As the veſſels are always cleaned under this fountain, cloths and bottle bruſhes ought to be hung upon hooks faſtened in the walls near it.

In the middle of the laboratory a large table is to be placed, on which mixtures are to be made, preparations for operations, ſolutions, precipitations, ſmall

ſmall filtrations; in a word, whatever does not require fire, excepting that of a lamp.

In convenient parts of the laboratory are to be placed blocks of wood upon mats; one of which is to ſupport a middle-ſized iron mortar; another to ſupport a middle-ſized marble, or rather hard ſtone mortar; a third to ſupport an anvil. Near the mortars are to be hung ſcarces of different ſizes and fineneſs; and near the anvil are hung a hammer, files, raſps, ſmall pincers, ſciſſars, ſheers, and other ſmall utenſils neceſſary to give metals a form proper for the ſeveral operations.

Two moveable treſtles ought to be in a laboratory, which may ſerve to ſupport a large filter mounted upon a frame, when it is required. This apparatus is removed occaſionally to the moſt convenient place.

Charcoal is an important article in a laboratory, and it therefore muſt be placed within reach; but as the black duſt which flies about it whenever it is ſtirred is apt to ſoil every thing in the laboratory, it had better be in ſome place near the laboratory, together with ſome furze, which is very convenient for kindling fires quickly. This place ſerves, at the ſame time, for containing bulky things which are not often wanted; ſuch as furnaces, bricks, tiles, clay, fire-clay, quick-lime, ſand, and many other things neceſſary for chemical operations.

Laſtly, a middle-ſized table, with ſolid feet, ought to be enumerated amongſt the large moveables of a laboratory, the uſe of which is to ſupport a porphyry, or levigating ſtone, or rather a very hard and denſe grit-ſtone, together with a grinder made of the ſame kind of ſtone.

The other ſmall moveables or utenſils of a laboratory are, ſmall hand mortars of marble, iron and glaſs, and their peſtles; earthen, ſtone, metal, and glaſs veſſels.

Some white writing paper, and ſome paper not glued for filtrations; a large number of clean ſtraws, eight or ten inches long, for ſtirring mixtures in glaſſes, and for ſupporting paper filters placed in glaſs funnels.

Glaſs tubes for ſtirring and mixing corroſive liquors; ſpatulas of wood, ivory, metal, and of glaſs.

Thin paſteboards, and horns, very convenient for collecting matters bruiſed with water upon the levigating ſtone, or in mortars; corks of all ſizes; bladders and linen ſtrips for luting veſſels.

A good portable pair of bellows; a good ſteel for ſtriking fire; a glue pot, with its little bruſh; laſtly, a great many boxes of various ſizes, for containing moſt of the above-mentioned things, and which are to be placed upon the ſhelves.

Beſides theſe things, ſome ſubſtances are ſo neceſſary in moſt chemical operations, that they may be conſidered as inſtruments neceſſary for the practice of this ſcience. Theſe ſubſtances are:

All metals and ſemi-metals, which ought to be very pure.

Vitriolic acid, ſome of which ought to be concentrated and rectified, and alſo ſome of that ſort commonly ſold by druggiſts.

Aqua fortis, ſuch as is commonly ſold, and is cheap; alſo ſpirit of nitre moderately ſtrong, but very pure: the ſame acid very pure, concentrated, and ſmoking.

Common ſpirit of ſalt, ſome of the ſame acid very pure, very ſtrong, and ſmoking. All theſe acids ought to be kept in cryſtal glaſs bottles, and cloſed with glaſs ſtoppers.

Some

Some diſtilled vinegar, which may be kept in an ordinary bottle; ſome radical vinegar, which ought to be kept in a bottle with a glaſs ſtopper; ſome cream of tartar, in an earthen or glaſs veſſel, or in a box.

Common fixed vegetable alkali, very dry, ſuch as pot aſh, which muſt be kept in a well cloſed bottle. The ſame alkali in a liquid ſtate.

Very pure ſalt of tartar, ſome dry, and ſome liquid.

Mineral alkali, liquid; that is, a ſolution of ſoda. The ſame alkali dry and very pure; that is, well formed cryſtals of ſoda.

The two fixed alkalis liquid, and rendered cauſtic by quick-lime. Alkalis, particularly thoſe which are cauſtic, ought to be kept in bottles with glaſs ſtoppers. Some phlogiſticated fixed alkali, or even ſaturated, ſo as to be fit for making Pruſſian blue.

Some dry liver of ſulphur kept in a well cloſed bottle. The ſame liquid. Some common ſulphur.

Very pure alkali of ſal-ammoniac, diſengaged by a fixed alkali, ſome ſolid, and ſome liquid, kept in a bottle with a glaſs ſtopper.

Volatile alkali from ſal-ammoniac diſengaged by quick-lime, as ſtrong as is poſſible. Some of this may be kept of leſs ſtrength.

Lime water, and quick-lime, in well cloſed bottles.

The pureſt and higheſt rectified ſpirit of wine.

Good vitriolic ether.

Rectified eſſential oil of turpentine; oil of olives; ſoap.

Galls; ſyrup of violets; tincture of turnſol, or turnſol in rags; fine blue paper; river or diſtilled rain-water.

Beſides theſe ſubſtances, moſt of which are ſolvents, certain neutral ſalts ought to be had which are frequently uſed in chemical operations, or are difficultly prepared. Theſe are:

Vitriolated tartar; alum, and calcined alum; green vitriol; blue vitriol; nitre; decrepitated common ſalt; ſome of the ſame ſalt very pure, diſſolved in diſtilled water; purified ſal-ammoniac; calcined borax; ſedative ſalt.

A pure ſolution of ſilver in ſpirit of nitre; a ſolution of mercury in the ſame acid; butter of antimony. All theſe to be kept in bottles with glaſs ſtoppers. Corroſive ſublimate.

Ceruſs; letharge; minium; ſand waſhed and ground; white marble; waſhed chalk; glaſs of lead; glaſs of borax.

A perſon provided with the above-mentioned inſtruments and ſubſtances may at once perform any chemical experiment. He may indeed occaſionally want ſeveral neutral ſalts which have not been named; but all theſe ſalts with baſes of earths, metals, fixed or volatile alkalis, may be eaſily and inſtantly prepared, as moſt of them do not require diſtillation or ſublimation. They may nevertheleſs, if they are not too numerous, be all previouſly prepared and kept ready for any occaſion.

The general obſervations of Macquer upon the conducting of chemical proceſſes are truly valuable and judicious. Method, order, and cleanlineſs, are eſſentially neceſſary in a chemical laboratory. Every veſſel and utenſil ought to be well cleanſed as often as it is uſed, and put again into its place: inſcriptions ought to be faſtened upon all the ſubſtances. Theſe cares, which ſeem to be trifling, are however very fatiguing and tedious; but they alſo are very important, though frequently little obſerved. When a perſon is keenly engaged, experiments ſucceed each other quickly; ſome ſeem nearly to decide the matter,

and others ſuggeſt new ideas: he cannot but proceed to them immediately, and he is led from one to another: he thinks he ſhall eaſily know again the products of the firſt experiments, and therefore, he does not take time to put them in order: he proſecutes with eagerneſs the experiments which he has laſt thought of; and in the mean time, the veſſels employed, the glaſſes and bottles filled, ſo accumulate, that he cannot any longer diſtinguiſh them; or at leaſt, he is uncertain concerning many of his former products. This evil is increaſed if a new ſeries of operations ſucceed, and occupy all the laboratory; or if he is obliged to quit it for ſome time: every thing then goes into confuſion. Thence it frequently happens that he loſes the fruits of much labour, and that he muſt throw away almoſt all the products of his experiments.

The only method of avoiding theſe inconveniences is to employ the cares and attentions above-mentioned. It is indeed diſagreeable to ſtop continually in the middle of the moſt intereſting reſearches, and to employ a very precious and conſiderable time in cleaning veſſels, arranging them, faſtening inſcriptions on them, &c. Theſe employments are capable of cooling or retarding the progreſs of genius, and are tedious and diſguſtful; but they are nevertheleſs neceſſary. Thoſe perſons whoſe fortune enables them to have an aſſiſtant operator, on whoſe exactneſs and intelligence they can depend, avoid many of theſe diſagreeable circumſtances; but they ought nevertheleſs to attend to the execution of theſe things. We cannot depend too much on ourſelves in theſe matters, however minute, on account of their conſequences. This becomes even indiſpenſable when the experiments are to be kept ſecret, at leaſt for a time; which is often neceſſary in chemiſtry.

When new reſearches and inquiries are made, the mixtures, reſults, and products of all the operations ought to be kept a long time, diſtinctly labelled and regiſtered; for theſe things, when kept ſome time, frequently preſent phenomena that were not at all ſuſpected. Many fine diſcoveries in chemiſtry have been made in this manner, and many have certainly been loſt by throwing away too haſtily, or neglecting the products.

It cannot be too much recommended to chemical operators to be exceedingly upon their guard againſt impoſing and deceitful experiments, which frequently preſent themſelves in practice. A circumſtance ſeemingly unimportant, or not eaſily perceptible, is frequently ſufficient to give the appearance of a great diſcovery, by means of certain effects, which, nevertheleſs, are found to proceed from ſome other cauſe. Chemical experiments depend on ſo many acceſſary things, that all of them can ſeldom be attended to, particularly when the ſubject is new: hence we frequently find that very different reſults proceed from the ſame experiments, and at different times. We therefore muſt not decide after the firſt ſucceſs; but the experiment muſt be repeated ſeveral times, and even varied, till no doubt can remain.

Since chemiſtry offers many views for the improvement of many important arts; as it preſents proſpects of many uſeful and profitable diſcoveries; thoſe who apply their labours in this way ought to be exceedingly circumſpect not to be led into an uſeleſs expence of money and time. Thoſe reſearches which have ſome analogy with the philoſopher's ſtone, from the hopes of wealth which they ſuggeſt, are alſo attended with ſimilar danger. In a certain ſet of experiments ſome one is generally of an impoſing appearance, although in reality it be nothing more. Chemiſtry is full of theſe half ſucceſſes, which ſerve only to deceive the unwary, to multiply the number of trials, and to lead to great expence before the

the fruitleſſneſs of the ſearch be diſcovered. By theſe reflections we do not intend to divert from all ſuch reſearches thoſe whoſe taſte and talents render them fit for them; on the contrary, we acknowledge that the improvement of the arts, and the diſcovery of new objects of manufacture and commerce, are undoubtedly the fineſt and moſt intereſting part of chemiſtry, and which make that ſcience truly valuable; for without theſe ends what would chemiſtry be but a ſcience purely theoretical, and capable of employing only ſome abſtract and ſpeculative minds, but uſeleſs to ſociety? We acknowledge alſo, that the ſucceſſes in this kind of chemical inquiry are not rare; and that their authors have ſometimes acquired fortunes, ſo much the more honourable as being the fruits of their talents and induſtry. But we repeat, that, in theſe reſearches, the more dazzling and near any ſucceſs appears, the more circumſpection, and even diſtruſt is neceſſary. *See* ANALYSIS, APPARATUS, ATTRACTION, BALANCE, BLOW PIPE, FORGE FURNACE.

LABRADOR STONE. A beautiful ſtone from the coaſt of Labrador. Its colour is commonly of a light, or of a deep gray, frequently blackiſh; but when held in certain poſitions to the light, it exhibits varieties of beautiful internal colours, chiefly conſiſting of ſhades of blue and green, ſeldom yellow, in ſome parts of a copper red, and violet. Theſe colours have for the moſt part a flaky or ſpotted appearance, but ſometimes they lie in ſtripes.

Theſe ſtones are found of an angular form in pieces of conſiderable magnitude, their ſpecific gravity is 2.755, their fracture is laminated; the broken parts are rhomboidal, and ſemi-tranſparent. In other reſpects this ſtone agrees with the felt ſpar, but is ſofter.

LAC, or LACCA. Is a ſubſtance well known in Europe, under the different appellations of ſtick-lac, ſhell-lac, and ſeed-lac. The firſt is the lac itſelf, which is a brown ſemi-tranſparent ſubſtance, in pretty conſiderable lumps, with woody parts adhering to it. Seed-lac is the ſtick-lac broken in pieces, and appearing in a granulated form. Shell-lac is the ſubſtance which has undergone a ſimple purification.

Lac is the product of an inſect*, which depoſits its eggs on the branches of a tree called Bihar, in Aſſam, a country bordering on Thibet, and elſewhere in India. It appears deſigned to anſwer the purpoſe of defending the eggs from injury, and affording food for the maggot in a more advanced ſtate. It is formed into cells, finiſhed with as much art and regularity as an honey-comb, but differently arranged; and the inhabitants collect it twice a year, in the months of February and Auguſt. For the purification, it is broken into ſmall pieces, and put into a canvas bag of about four feet long, and not above ſix inches in circumference. Two of theſe bags are in conſtant uſe, and each of them held by two men. The bag is placed over a fire, and frequently turned, till the lac is liquid enough to paſs through its pores; when it is taken off the fire, and twiſted in different directions by the men who hold it, at the ſame time dragging it along the convex part of a plantain tree prepared for that purpoſe; and while this is doing, the other bag is heating, to be treated in the ſame way. The mucilaginous and ſmooth ſurface of the plantain tree prevents its adhering; and the degree of preſſure regulates the thickneſs of the coating of lac, at the ſame time that the fineneſs of the bag determines its clearneſs and tranſparency.

Lac is not entitled to arrangement either with oils, reſins, or gums. It is

* For a deſcription, conſult Kerr, in the Phil. Tranſ. vol. lxxi. p. 374.

not ſoluble either in water, or in fat oils. Some eſſential oils appear to extract a dilute tincture. The action of the acids upon lac, either when concentrated or diluted, does not ſeem to be conſiderable; but this requires more particular examination; eſpecially as far as relates to the nitrous acid. Ardent ſpirit acts but feebly on this ſubſtance. By ſtanding upon it in the cold, it forms a clear tincture, apparently by diſſolving only a part of its principles; but, when digeſted in a moderate heat, the whole of the lac unites with the ſpirit, and forms a turbid mixture, or imperfect ſolution, of a gummy appearance, which does not afterwards become clear. In this way, however, with judicious management, it appears practicable to form a very hard opake varniſh, reſembling that of China or Japan. The principal uſe of lac is in the manufacturing of ſealing-wax, and in dyeing ſcarlet. For this laſt purpoſe, half a dram of powdered comfrey root is to be boiled in a quart of water for a quarter of an hour, and ſome powdered gum lac digeſted in the decoction for two hours. The tincture appears of a fine crimſon colour; and the remaining lac, if the quantity of liquor has been ſufficient, is of a pale ſtraw colour. The clear tincture being then poured off, and a ſolution of alum gradually added, the colouring matter ſubſides, in the form of one of the powders called lakes, which amounts to about one-fifth part of the weight of the lac. This fecula is diſſolved in warm water, with the addition of a proper quantity of the ſolution of tin in aqua regia: and the liquor, which is of a fiery red colour, is then to be poured into boiling water, impregnated with ſalt of tartar, or the mild fixed vegetable alkali. The bath, thus formed, is a good ſcarlet dye for woollens, though leſs lively than that of cochineal.

LACQUER. See VARNISH.

LAKE. This term is uſed to denote a ſpecies of colours formed by combining the earth of alum, or calx of tin, with the colouring matter of certain vegetables. The principal lakes are, Carmine, Florence-lake, and lake from Madder.

For the preparation of *Carmine*, four ounces of finely pulverized cochineal are to be poured into four or ſix quarts of rain or diſtilled water, that has been previouſly boiled in a pewter kettle, and boiled with it for the ſpace of ſix minutes longer; (ſome adviſe to add, during the boiling, two drachms of pulverized cryſtals of tartar). Eight ſcruples of Roman alum in powder, are then to be added, and the whole kept upon the fire one minute longer. As ſoon as the groſs powder has ſubſided to the bottom, and the decoction is become clear, this latter is to be carefully decanted into large cylindrical glaſſes covered over, and kept undiſturbed, till a fine powder is obſerved to have ſettled at the bottom. The ſuperincumbent liquor is then to be poured off from this powder, and the powder gradually dried. From the decanted liquor, which is ſtill much coloured, the reſt of the colouring matter may be ſeparated by means of the ſolution of tin, when it yields a carmine little inferior to the other.

For the preparation of *Florentine* lake, the ſediment of cochineal that remained in the kettle, may be boiled with the requiſite quantity of water, and the red liquor likewiſe that remained after the preparation of the carmine, mixed with it, and the whole precipitated with the ſolution of tin. The red precipitate muſt be frequently edulcorated with water. Excluſively of this, two ounces of freſh cochineal, and one of cryſtals of tartar, are to be boiled with a ſufficient quantity of water, poured off clear, and precipitated with a ſolution of tin, and the precipitate waſhed. At the ſame time two pounds of alum are alſo to be diſſolved

in water, precipitated with a lixivium of pot-aſh, and the white earth repeatedly waſhed with boiling water. Finally, both precipitates are to be mixed together in their liquid ſtate, put upon a filter, and dried. For the preparation of a *cheaper* ſort, inſtead of cochineal, one pound of Brazil wood may be employed in the preceding manner.

Madder lake, which was mentioned long ago by Neri, and has been ſince diſcovered afreſh by Margraff, is made by diſſolving two ounces of Roman alum in ſix pounds of boiling water, and to this adding two ounces of fine madder, with which the water is ſuffered to boil once or twice more, and then to ſtand for ſome time in digeſtion. The decoction being afterwards filtered, a ſolution of alkali is to be mixed with it till no farther precipitation enſues.

LAMP. See LIGHT.

LAMP BLACK. When the parts of organized ſubſtances which are of an inflammable nature are burning under circumſtances wherein a complete combuſtion does not take place, part of the coaly matter is carried up through the flame, and forms ſoot. Common ſoot contains other matters beſides charcoal: but the ſoot of oily ſubſtances is conſiderably pure. The fineſt lamp-black is actually produced by collecting the ſmoke from a lamp with a long wick, which ſupplies more oil than can be perfectly conſumed, or by ſuffering the flame to play againſt a metalline cover, which impedes the combuſtion not only by conducting off part of the heat, but by obſtructing the current of air. Lamp-black, however, is prepared in a much cheaper way, for the demands of trade. The dregs which remain after the eliquation of pitch, or elſe ſmall pieces of fir-wood, are burned in furnaces of a peculiar conſtruction, the ſmoke of which is made to paſs through a long horizontal flue, terminating in a cloſe boarded chamber. The roof of this chamber is made of coarſe cloth, through which the current of air eſcapes, while the ſoot remains behind. See LIGHT.

LAPIS HEPATICUS. A ſtone of a white, grey, yellow, brown, or black colour; it is generally compact, but not ſo hard as to give fire with ſteel; of a texture either equable or laminar, ſcaly or ſparry, and which takes a poliſh as alabaſter.

It does not effervеſce with acids. When calcined, it is partially reduced to a ſort of Plaiſter of Paris. It emits a ſmell of hepar ſulphuris, at leaſt when rubbed. According to Bergman, 100 parts of it afford 33 of baroſelenite, 38 of ſilex, 22 of alum, 7 of gypſum, and 5 of mineral oil. The increaſe proceeds from the water of cryſtallization.

LAPIS INFERNALIS. See INFERNAL STONE.

LAPIS LAZULI. The colour of this ſtone is a beautiful opake blue, which varies a little in intenſity, and is generally ſprinkled over with yellow, bright, pyritaceous ſpecks or ſtreaks: it obſtinately retains its colour in a ſtrong heat, which diſtinguiſhes it from other blue ſtones: it is of an equable or very fine granular texture, and takes a beautiful poliſh: its ſpecific gravity is 3.054.

If powdered and not calcined, it effervеſces very ſlightly with acids; but if calcined, it does not effervеſce, but becomes gelatinous.

In a ſtrong fire it melts without addition into a whitiſh glaſs. From the experiments of Cronſtedt and Margraff this ſtone does not appear to contain copper. The latter found lime, vitriolic acid, iron, and ſilex; Rinman has ſince diſcovered it to contain the acid of ſpar. If the colour be owing to the iron, we are ſtill unacquainted with the modification by which it remains permanent in a ſtrong heat.

LAPIS

LAPIS LYDIUS. A variety of the trapp of the Swedes; its colour is black, and it is well known by the name of the touch-ſtone. The black baſaltes, from which this ſtone ſcarcely differs in its component parts, is uſed for the ſame purpoſe. See ASSAY.

LAPIS NEPHRITICUS. See JADE.

LAPIS OBSIDIANUS. The lapis obſidianus of Pliny appears to have been a volcanic product, reſembling the black baſaltes, but in a higher ſtate of vitrification.

LAPIS OLLARIS, or ſoap rock. A ſtone of the magneſian genus, of a yellow colour, ſometimes whitiſh, and but rarely black. It is eaſily wrought and turned, ſo that pots and mortars are often made of it.

LAPIS SPECULARIS. A name given to the tranſparent gypſeous ſpar, or combination of vitriolic acid and lime.

LAPIS SUILLUS. See LAPIS HEPATICUS.

LAVA. See VOLCANIC PRODUCTS.

LAUDANUM. See OPIUM.

LAZULI, LAPIS. See LAPIS LAZULI.

LEAD. Is a white metal, of a conſiderably blue tinge, very ſoft and flexible, not very tenacious, and conſequently incapable of being drawn into fine wire, though it is eaſily extended into thin plates under the hammer. Its weight is very conſiderable, being rather greater than that of ſilver. Long before ignition, namely at about the 540th degree of Fahrenheit's thermometer, it melts; and then begins to be calcined, if reſpirable air be preſent. In a ſtrong heat it boils, and emits fumes; during which time, if expoſed to the air, its calcination proceeds with conſiderable rapidity. If melted lead be poured into a box previouſly rubbed with chalk to prevent its action on the wood, and be continually agitated, it will concrete into ſeparate grains, of conſiderable uſe in various mechanical operations, particularly that of weighing. Lead is brittle at the time of congelation. In this ſtate it may be broken to pieces with a hammer, and the cryſtallization of its internal parts will exhibit an arrangement in parallel lines.

This metal, during the progreſs of heat, firſt becomes converted into a duſky powder, which by a continuation of the heat becomes white, yellow, and afterwards of a bright-red, inclining to orange colour, called minium, or red lead. The proceſs requires conſiderable management with regard to the heat, and acceſs of the air in the making of red lead. Many days are required for this purpoſe. If the heat be too great or rapid, the lead becomes converted into a flaky ſubſtance, called litharge; and a ſtill greater heat converts it into a clear, tranſparent, yellow glaſs, which powerfully diſſolves and corrodes metallic calces or earths; and on this account it uſually finds its way through the crucibles in a ſhort time. It acts more difficultly on argillaceous than on ſiliceous earths; whence it is found, that veſſels made of clay mixed with broken pottery, are preferable to thoſe that are compoſed of clay and ſand. The calx of lead is a principal ingredient in moſt of the modern fine white glaſſes. It is more particularly calculated to form the denſe glaſs uſed to correct the aberration ariſing from colour in thoſe teleſcopes, which are known by the name of achromatic; becauſe it communicates the property of ſeparating the coloured rays from each other, in greater angles than obtained in alkaline glaſſes at equal angles of mean refraction. See ACHROMATIC, alſo GLASS. The imperfection which moſt conſiderably affects this kind of glaſs is, that its denſity is

ſeldom uniform throughout. The irregularities ſhew themſelves in the form of veins, which greatly diſturb the regular refraction.

Lead is not much altered by expoſure to air or water, though the brightneſs of its ſurface, when cut or ſcraped, very ſoon goes off. It is probable that a thin ſtratum of calx is formed on the ſurface, which defends the reſt of the metal from corroſion.

Moſt of the acids attack lead. The vitriolic acid does not act upon it, unleſs it be concentrated and boiling. Vitriolic acid air eſcapes during this proceſs, and the acid is decompoſed. When the diſtillation is carried on to dryneſs, a ſaline white maſs remains, a ſmall portion of which is ſoluble in water, and is the vitriol of lead: it affords cryſtals. The reſidue of the white maſs is a calx of lead.

Nitrous acid acts ſtrongly on lead, and converts it into a white calx, if the acid be concentrated; but if it be more diluted, the calx is diſſolved, and forms a a nitre of lead which is cryſtallizable, and does not afford a precipitate by cooling. It detonates on ignited coals. Lime and alkalis decompoſe the nitrous ſolution of lead. The vitriolic acid added to this ſolution combines with the metallic calx, and falls down. The marine acid in the ſame manner carries down the lead, and forms a combination called plumbum corneum, which is more ſoluble in water than the horn ſilver.

Marine acid acts directly on lead by heat, which it calcines, and diſſolves part of its calx. The marine ſalt of lead is cryſtallizable.

The acetous acid diſſolves lead and its calces; though probably the acceſs of air may be neceſſary to the ſolution of the metal itſelf in this acid. White lead, or ceruſe, is made by rolling leaden plates ſpirally up, ſo as to leave the ſpace of about an inch between each coil, and placing them vertically in earthen pots, at the bottom of which is ſome good vinegar. The pots are to be covered, and expoſed for a length of time to a gentle heat in a ſand bath, or by bedding them in dung. The vapour of the vinegar, aſſiſted by the tendency of the lead to combine with the pure part of the air which is preſent, corrodes the lead, and converts the external portion into a white calx, which comes off in flakes, when the lead is uncoiled. The plates are thus treated repeatedly until they are corroded through. Ceruſe is the only white ſubſtance uſed in oil paintings. It may be diſſolved without difficulty in the acetous acid, and affords a cryſtallizable ſalt, called ſugar of lead from its ſweet taſte. This, like all the preparations of lead, is a moſt deadly poiſon.

Liver of ſulphur precipitates lead from its ſolutions, the ſulphur falling down in combination with the lead. Pure alkaline ſolutions diſſolve a ſmall portion of lead, and corrode a conſiderable quantity: the ſolution is ſaid to give a black colour to the hair.

Oils diſſolve the calces of lead, and become thick and conſiſtent; in which ſtate they are uſed as the baſis of plaſters, cements for water works, paints, &c.

In the dry way, lead alone is calcined and vitrified. When fuſed with fixed alkaline ſalts, it is converted into a dark-coloured ſcoria, partly ſoluble in water. The neutral ſalts in general are not acted upon by lead. Nitre calcines this metal when treated with it, though ſcarcely any commotion or apparent flame is produced by its action. Sulphur readily diſſolves it in the dry way, and produces a brittle compound, of a deep gray colour and brilliant appearance, which is much leſs fuſible than lead itſelf, a property which is common to all the combinations of ſulphur with the more fuſible metals.

The

The phoſphoric acid, expoſed to heat together with charcoal and lead, becomes converted into phoſphorus, which combines with the metal. This combination does not greatly differ from ordinary lead; it is malleable, and eaſily cut with a knife; but it loſes its brilliancy more ſpeedily than pure lead; and when fuſed upon charcoal with the blow-pipe, the phoſphorus burns, and leaves the lead behind.

Lead decompoſes ſal ammoniac by the aſſiſtance of heat; its calces unite with the marine acid of that ſalt in the cold, and diſengage its volatile alkali. When volatile alkali is obtained by diſtilling ſal ammoniac with the calces of lead, the reſidue conſiſts of plumbum corneum.

Litharge fuſed with common ſalt decompoſes it; the lead unites with the marine acid, and forms a yellow compound, at preſent uſed in this country as a pigment, for which an excluſive privilege has been granted. The alkali either floats at top, or is volatilized by the heat, if ſtrongly urged. The ſame decompoſition takes place in the humid way, if common ſalt be macerated with litharge; and the ſolution will contain cauſtic alkali.

Lead unites with moſt of the metals. Gold and ſilver are diſſolved by it in a ſlight red heat. Both theſe metals are ſaid to be rendered brittle by a ſmall admixture of lead, though lead itſelf is rendered more ductile by a ſmall quantity of them. Platina forms a brittle compound with lead; mercury amalgamates with it; but the lead is ſeparated from the mercury by agitation, in the form of an impalpable black powder, vital air being at the ſame time abſorbed. The preſence of vital air is indiſpenſably neceſſary in this proceſs. Copper and lead do not unite but with a ſtrong heat. If lead be heated ſo as to boil and ſmoke, it ſoon diſſolves pieces of copper thrown into it; the mixture when cold is brittle. The union of theſe two metals is remarkably ſlight; for upon expoſing the maſs to a heat no greater than that in which lead melts, the lead almoſt entirely runs off by itſelf. This proceſs, which is peculiar to lead with copper, is called eliquation. The coarſer ſorts of lead, which owe their brittleneſs and granulated texture to an admixture of copper, throw it up to the ſurface on being melted by a ſmall heat. Iron does not unite with lead, as long as both ſubſtances retain their metallic form. Tin unites very eaſily with this metal, and forms a compound which is much more fuſible than lead by itſelf, and is for that reaſon uſed as a ſolder for lead. Two parts of lead and one of tin form an alloy more fuſible than either metal alone: this is the ſolder of the plumbers. Biſmuth combines readily with lead, and affords a metal of a fine cloſe grain, but very brittle. A mixture of eight parts biſmuth, five lead, and three tin, will melt in a heat which is not ſufficient to cauſe water to boil. Regulus of antimony forms a brittle alloy with lead. Wolfram unites with it into a ſpungy ductile compound, which ſplits into leaves when hammered. Nickel, cobalt, manganeſe, and zinc, do not unite with lead by fuſion.

All the calces of lead are very eaſily revived. Minium, when expoſed to a ſtrong heat, gives out part of the vital air it abſorbed during its calcination; but, like the other calces of this metal, it requires the addition of ſome combuſtible ſubſtance for its complete revival. A familiar inſtance of this revival is ſeen by expoſing the common wafers to the flame of a candle. Theſe wafers are coloured with minium, which is revived by the heat and inflammable ſubſtance of the wafer, ſo that it falls down in metallic globules.

Lead is found native, though ſeldom; and alſo in the form of a calx, called native ceruſe, or lead ochre, or lead ſpar of various colours, red, brown, yellow, green, blueiſh, and black. Theſe ores, when freed as much as poſſible from earthy

earthy matter, may be diſſolved in diluted nitrous acid. Calx of iron is uſually thrown down from the ſolution by boiling. If the lead be then precipitated by the mild mineral alkali, and weighed, 132 grains of the dry precipitate will correſpond with 100 grains of lead in the metallic ſtate. If the precipitate be ſuſpected to contain copper, it may be ſeparated by digeſting in volatile alkali. If it be ſuppoſed to contain ſilver and copper, the precipitate may again be diſſolved in nitrous acid, and ſeparated by the addition of marine acid; which combining with the metal, produces luna cornea, and plumbum corneum; the latter of which, being ſoluble in 30 times its weight of boiling water, may be waſhed off, while the ſilver remains undiſſolved; or the ſilver, if alone in the precipitate, may be taken up by volatile alkali, which will leave the calx of lead of the ſame value with regard to weight as the foregoing. Lead is alſo found mineralized by the vitriolic and the phoſphoric acids: this laſt is of a greeniſh colour, ariſing from a mixture of iron. The vitriol of lead is ſoluble in about 18 times its weight of water. One hundred and forty-three grains of the dried ſalt repreſent 100 grains of lead. The phoſphoric lead ore may be diſſolved in nitrous acid by means of heat, except a few particles of iron, which remain at the bottom. By the addition of vitriolic acid, the lead is thrown down in the form of white flakes of vitriol, which when waſhed and dried, diſcover the quantity of lead they contain, by the ſame allowance of 143 grains of the ſalt to 100 grains of metallic lead. The remaining ſolution being evaporated to dryneſs, affords phoſphoric acid.

Lead is abundantly found in combination with ſulphur, in the form of heavy, ſhining, black, or blueiſh lead-coloured cubical maſſes, whoſe corners are uſually truncated; its texture is laminated, and its hardneſs variable. This is called galina, or potters lead ore. Moſt lead ores contain more or leſs of ſilver. When antimony enters into its compoſition, the texture is radiated or filamentous. There are alſo lead pyrites, which contain a conſiderable proportion of iron and ſulphur; and red lead ſpar, which conſiſts of lead mineralized by ſulphur and arſenic; this is very ſcarce.

If ſulphurated lead be boiled in nitrous or marine acid of a moderate ſtrength, the ſulphur may be obtained pure, and collected in a filter. When iron or ſtony particles are contained among the undiſſolved part, the ſulphur may be ſeparated by digeſtion in a ſolution of cauſtic fixed alkali, which converts it into liver of ſulphur, and leaves the other inſoluble matters behind. If the firſt ſolution be made with nitrous acid, it may contain ſilver and lead, which, after the precipitation by mild mineral alkali, may be ſeparated by the volatile alkali, as mentioned in the humid analyſis of the calciform ores: when the marine acid is uſed for the ſolution of the ore, a large quantity of plumbum corneum ſeparates, for want of a ſufficient quantity of water to diſſolve it. This requiſite quantity of water muſt be added to diſſolve the ſalt, before the precipitate is made by the fixed alkali.

All the ores of lead, except the phoſphoric, are reducible to the metallic ſtate, by diſſipating their volatile contents by the blow-pipe on a piece of charcoal. In the large way, they are revived by fuſion with charcoal.

The ores of this metal are abundantly found in the mine counties of England, and in various other parts of the globe. Its uſes are numerous, and ſcarcely need be mentioned. Its calces have been already mentioned as of great uſe, as a pigment, and in the manufacture of glaſs. Lead is caſt into thin ſheets for cover-

ing buildings, making water pipes, and various other uſes; and this is rolled between two cylinders of iron, to give it the requiſite uniformity and thinneſs. Lead is thought, and with ſome reaſon, to be not perfectly innocent even for water pipes, and much leſs for any other kind of veſſels. The workmen in any of the preparations of lead are generally ſubject to a peculiar cholic, and paralytic diſorders; which moſt probably ariſe from the internal uſe of the metal: for it is a fact that theſe workmen are not ſufficiently cautious in waſhing their hands, or removing ſuch particles of lead, or its preparations, as may caſually intermix with their food.

LEATHER. The ſkins of animals prepared by maceration in lime-water, and afterwards with aſtringent ſubſtances. See TANNING.

LEAVES OF PLANTS. Lewis found * that the green colour of the leaves of plants is extracted by rectified ſpirit, and by oils. The ſpirituous tinctures are generally of a fine deep green, even when the leaves are dull coloured, yellowiſh, or hoary. Theſe colours are ſeldom laſting in the liquor. Alkalis heighten both the tinctures and the green juices. Acids weaken, deſtroy, and change it to a browniſh. Lime-water improves both the colour and durability. By means of lime, not inelegant green lakes are procurable from the leaves of acanthus, lily of the valley, and ſeveral other plants.

Few plants communicate any part of their green colour to water, and perhaps none that give a green of any conſiderable intenſity. It is ſaid, however, that the leaves of ſome plants give a green dye to woollen, without the addition of any other colouring matter; particularly thoſe of the wild chervil, or cow-weed, the common rag-wort and devil's bit. Lewis gives the proceſs from Linnæus as practiſed by the peaſants in Sweden with this laſt. It conſiſts in boiling the leaves with their woollen yarn for a ſhort time, and leaving the whole together for a night, after which the yarn is taken out, and hung in the ſteam of the liquid, again made to boil over the fire. It is then wrung, the leaves are taken out of the liquor, a little freſh water added, and the wool frequently dipped therein till ſufficiently dyed.

Many kinds of leaves afford a yellow dye to woollens previouſly boiled with alum and tartar, weld in particular, which ſee. Indigo and woad afford blue. Lewis tried, without ſucceſs, to obtain blues by macerating the leaves of other plants in water.

LEES, SOAP. See ALKALI FIXED. Alſo SOAP.

LEMNIAN EARTH. See EARTH, FULLERS.

LEMONS. The juice of lemons, or limes, has all the characters of an acid of conſiderable ſtrength. On account of the mucilaginous matter with which it is mixed in its firſt ſtate, it is very ſoon altered by ſpontaneous decompoſition. Various methods have been contrived to prevent this effect from taking place, in order that this wholeſome and agreeable acid might be preſerved for uſe in long voyages, or other domeſtic occaſions. The juice may be kept in bottles under a thin ſtratum of oil, which indeed prevents, or greatly retards, its total decompoſition; though the original freſh taſte ſoon gives place to one which is much leſs grateful. In the Eaſt Indies it is evaporated to the conſiſtence of a thick extract. If this operation be carefully performed by a very gentle heat, it is found to be very effectual. When the juice is thus heated, the mucilage

* On Neumann, ii. 236.

thickens,

thickens, and ſeparates in the form of flocks; part of which ſubſides, and part riſes to the ſurface: theſe muſt be taken out. The vapours which ariſe are not acid. If the evaporation be not carried ſo far as to deprive the liquid of its fluidity, it may be long preſerved in well cloſed bottles; in which, after ſome weeks ſtanding, a farther portion of mucilage is ſeparated, without any perceptible change in the acid.

Of all the methods of preſerving lemon juice, that of concentrating it by froſt appears to be the beſt; though, in the warmer climates, it cannot conveniently be practiſed. Lemon juice, expoſed to the air in a temperature of between 50° and 60°, depoſits in a few hours a white ſemi-tranſparent mucilaginous matter, which leaves the fluid, after decantation and filtration, much leſs alterable than before. This mucilage is not of a gummy nature, but reſembles the gluten of wheat in its properties: it is not ſoluble in water, when dried. More mucilage is ſeparated from lemon juice by ſtanding in cloſed veſſels. If this depurated lemon juice be expoſed to a degree of cold of about ſeven or eight degrees below the freezing point, the aqueous part will freeze, and the ice may be taken away as it forms; and if the proceſs be continued until the ice begins to exhibit ſigns of acidity, the remaining acid will be found to be reduced to about one-eighth of its original quantity, at the ſame time that its acidity will be eight times as intenſe; as is proved by its requiring eight times the quantity of alkali to ſaturate an equal portion of it. This concentrated acid may be kept for uſe; or, if preferred, it may be made into a dry lemonade, by adding ſix times its weight of fine loaf ſugar in powder*.

The above proceſſes may be uſed when the acid of lemons is wanted for domeſtic purpoſes; becauſe they leave it in poſſeſſion of the oils, or other principles, on which its flavour peculiarly depends. But in chemical reſearches, where the acid itſelf is required to be had in the utmoſt purity, a more elaborate proceſs muſt be uſed. Boiling lemon juice is to be ſaturated with powdered chalk, whoſe weight is to be noted. The neutral ſaline compound is ſcarcely more ſoluble in water than ſelenite: it therefore falls to the bottom; while the mucilage remains ſuſpended in the watery fluid, which muſt be decanted off. The remaining precipitate muſt then be waſhed with warm water until it comes off clear. To the powder, thus edulcorated, a quantity of vitriolic acid, ſufficient to ſaturate the chalk, and diluted with ten parts of water, muſt be added, and the mixture boiled a few minutes. The vitriolic acid combines with the lime, and forms ſelenite, which remains behind when the cold liquor is filtered; while the diſengaged acid of lemons remains diſſolved in the fluid. This laſt muſt be evaporated to the conſiſtence of a thin ſyrup; and vitriolic acid muſt then be added in ſmall portions, to precipitate the lime, if any ſhould ſtill remain in combination with acid of lemons. When no more precipitate is afforded by the addition of vitriolic acid, a farther evaporation ſeparates the pure acid of lemons in cryſtals. It is neceſſary that the vitriolic acid laſt added ſhould be rather in exceſs; becauſe the preſence of a ſmall quantity of lime will prevent the cryſtallization. This exceſs will be found in the mother water†.

The concrete acid of lemons remains conſiſtent in the air, is very ſoluble in water, and exhibits ſtrong acid properties. Its watery ſolution is decompoſed by a ſlow putrefaction. It unites with the alkalis and earths, ſilex excepted; and

* Georgius, quoted by Fourcroy, iv. 33.

† Scheele's Eſſays, Eng. tranſlation, p. 361; or Crell's Journal for 1784.

forms peculiar neutral ſalts, which have not yet been much examined. Several of the metallic ſubſtances are likewiſe acted upon by it; and it would probably diſſolve all their calces.

LEVIGATION. The mechanical proceſs of grinding the parts of bodies to a fine paſte, by rubbing the flat face of a ſtone called the muller upon a table or ſlab called the ſtone. Some fluid is always added in this proceſs, which circumſtance, together with the difference of the inſtruments, appears to conſtitute the diſtinction between this proceſs and trituration, which laſt is performed in a mortar upon powder, either dry or wetted. The advantage of levigation with a ſtone and muller, beyond that of triturating in a mortar, is, that the materials can more eaſily be ſcraped together, and ſubjected to the action of the muller, than in the other caſe to that of the peſtle.

LIGHT. Philoſophers are not agreed as to the independent exiſtence of light, or the cauſe by which we ſee; that is to ſay, whether light be a body, or a property. If light be a body, it muſt conſiſt of particles of extreme minuteneſs, projected with a very great degree of velocity from luminous bodies; if on the other hand light be nothing more than a modification or property, it muſt ſubſiſt in ſome other matter univerſally diffuſed through every part of known ſpace. The philoſophers who maintain this laſt opinion, conſider the univerſe to be occupied by a fluid of extreme rarity and elaſticity, permeating all bodies; the undulations of which, tranſmitted in all directions, from the luminous body, or exciting cauſe, produce the ſenſation and other effects of light. Though much ingenious reaſoning has been employed on this ſubject, we have not obtained poſſeſſion of any deciſive facts; but each hypotheſis may without inconſiſtency be applied to every natural appearance hitherto obſerved. It is difficult, however, to ſpeak of theſe facts, without conſidering light according to one or the other of theſe ſuppoſitions. This is not the place for diſcuſſing their reſpective merits. I ſhall therefore aſſume the hypotheſis which admits of the independent exiſtence of light, not only becauſe it is more generally admitted and known, but becauſe it appears beſt calculated to explain ſome of the appearances, more eſpecially the various refrangibility of the rays of light.

It is obſerved that whenever light paſſes through a ſpace occupied by a medium of uniform denſity, it deſcribes a right line. Theſe lines, or rather priſms, are called the rays of light. They rebound, or are reflected by bodies againſt which they ſtrike. It is ſufficiently aſcertained that this reflection is cauſed by a repulſive power in the body itſelf, exerted at a conſiderable diſtance; ſo that the light is driven back without coming into contact with the matter which repels it. When light is made to paſs near a body in ſuch a direction, or under ſuch circumſtances, as that it may come nearer than the limit of repulſion, it is attracted, and alters its courſe by deviating towards the attracting body. If the body poſſeſs a very narrow ſurface, ſuch for example as the edge of a knife, this deviation in the ray of light may be meaſured by attending to the courſe of the ray after it has paſſed the body. But if the ſurface be broader, the attractive power uſually cauſes the light to paſs into the body, where it is abſorbed and loſt, if the body be opaque, or paſſes through, if the body be tranſparent. The change produced in the courſe of a ray of light, by the attraction of a body into which the light does not enter, is called inflexion; but when the light does enter the body, this change is called refraction. It is found that the light of the ſun from which we derive the ſenſation of whiteneſs is compoſed of an admixture of rays poſſeſſing the property of exciting ſenſations of every poſſible colour, each according to its

reſpective nature. The attractive and repulſive powers of bodies differ in their intenſities with regard to theſe ſeveral rays, and accordingly they are ſeparated from each other by reflection, refraction, or inflection. A like ſeparation is alſo made in the rays of light by the thickneſs or diſtance between the two ſurfaces of the medium through which they paſs. It is more particularly obſervable in thin plates of glaſs, or water blown into bubbles, and the like. The colours of bodies depend on a power poſſeſſed by them of reflecting ſome of the rays of light, and abſorbing others, and this power in all probability depends upon the principles here ſketched out.

The velocity of light is ſo extremely great, that in all common experiments it appears to be inſtantaneous. Aſtronomers have nevertheleſs found that its progreſs acroſs the regions occupied by the ſolar ſyſtem requires ſo much time, that in computing the eclipſes of Jupiter's moons, they are under the neceſſity of making an allowance for the greater or leſs diſtance of that planet, which occaſions the time of any eclipſe to be later when ſeen from a greater diſtance than from a leſs. Other obſervations upon the fixed ſtars ſhew that there is a ſenſible proportion between the velocity of light, and that of the earth in its annual orbit. From theſe acute inveſtigations, it is deduced that light paſſes from the ſun to the earth in little more than eight minutes, which gives a velocity of about 167000 geographical miles in one ſecond.

Optical writers may be conſulted for a great number of curious and uſeful deductions made from theſe principles, and applied to the doctrine of viſion, the nature of colours, the conſtruction of mirrors, teleſcopes, and other inſtruments, not immediately within the province of chemiſtry.

Light comes to our eyes under ſix different circumſtances. 1. It is emitted from bodies in a rapid ſtate of combuſtion: or, 2. from other bodies at an elevated temperature, which are then ſaid to be ignited. 3. It alſo comes to us by 4, reflection; or 5, refraction: and 6, there are very few bodies which being expoſed to a ſtrong light, and afterwards taken into the dark, do not remain luminous for a conſiderable time. Hence it ſeems that we experimentally know of no other ſource of light, than combuſtion; and from this fact it is that many writers have conſidered fire, heat and light, to be the ſame thing. But theſe objects differ in various remarkable particulars. The heat of a fire is by no means proportional to the light it gives. The light will paſs through tranſparent bodies ſwiftly, and without impediment, but the heat remains attached to the body, and is not tranſmitted in any other way, than it would have paſſed through an opaque ſubſtance, viz. by raiſing the temperature of the body itſelf. Heat, with acceſs of pure air, cauſes bodies to be burned, and to loſe their combuſtible property. Light in many inſtances produces a contrary effect. The effect of light in chemical experiments is ſo conſiderable, that the operator ought to be conſtantly aware of the influence it may have upon his products. It appears to be particularly active in diſengaging vital air from its combinations; but whether by uniting with the air, or otherwiſe, has not been explained. Every chemiſt knows that pure pale nitrous acid cannot be preſerved but in bottles quite full, or in the dark. For the light expels vital air from the acid, if there be any ſpace into which it can eſcape, and leaves the reſidue yellow and fuming, in conſequence of the redundant portion of the baſis of the acid. Mere heat is ſo far from effecting this, that it reſtores the purity of the acid by expelling the redundancy. So likewiſe the black calx of manganeſe, which contains phlogiſticated air and vital air, emits the former at a low heat, but does not give out the latter until light be

preſent

preſent by the ignition of the veſſels. Light appears to be the great agent in the production of combuſtible matter on the ſurface of the globe. It extricates vital air from the leaves and other parts of vegetables, moſt probably by decompoſing their aqueous part, and leaves the combuſtible matter, or inflammable air, which enters into the compoſition of mucilages, oils, and reſins, the moſt inflammable of which are the products of ſuch climates as poſſeſs the greateſt intenſity of ſolar light. The conſequences of a want of light in vegetation, are remarkably ſhewn in the properties and chemical products of plants of the ſame kind, reared in the open day, or in the dark. The tendency of plants growing in a room, which turn themſelves towards the aperture which admits the light, or even towards the thinneſt ſide of a wooden box wherein they are included, is a ſtriking effect, and has been aſcribed to a degree of ſenſibility in theſe organized beings. But the evaporation of camphor and of water, the vegetation and cryſtallization of ſalts, and of metallic ſubſtances, which are conſiderably modified by light, and incline themſelves towards the place of its emiſſion, ſeem to be inſtances of the ſame kind. The metallic calces, and the ſalts produced by the aerated marine acid, undergo a change by the action of light, rendering them nearer the ſtate of combuſtibility than before.

Whence comes the light afforded by ignited bodies; whether it has been previouſly imbibed by them; whether the commencement of ignition be diſtinctive of the ſame temperature in all bodies; whether the great planetary ſources of light be bodies in a ſtate of combuſtion, or merely luminous upon principles very different from any which our experiments can point out; whether the momentum of the particles of light, or their diſpoſition for chemical combination be the moſt effectual in the changes produced by its agency;—theſe, and numerous other intereſting queſtions, muſt be left for future reſearch and inveſtigation.

The production of light by inflammation, is an object of great importance to ſociety at large, as well as to the chemiſt. It appears to ariſe immediately from the ſtrong ignition of a body, while rapidly decompoſing. Moſt ſolid bodies in combuſtion are kept, partly from a want of the acceſs of air, and partly from the vicinity of conducting bodies, at a low degree of ignition. But when vapours rapidly eſcape into the air, it may, and does frequently happen, that the combuſtion, inſtead of being carried on merely at the ſurface of the maſs, penetrates to a conſiderable depth within, and from this, as well as from the imperfect conducting power of the ſurrounding air, a white heat, or very ſtrong ignition is produced. The effect of lamps and candles depends upon theſe conſiderations. A combuſtible fluid, moſt commonly of the nature of fat oil, is put in a ſituation to be abſorbed between the filaments of cotton, linen, fine wire, or aſbeſtos. The extremity of this fibrous ſubſtance called the wick, is then conſiderably heated. The oil evaporates, and its vapour takes fire. In this ſituation the wick being inveloped with flame, is kept at ſuch a temperature that the oil continually boils, is evaporated, burns, and by that means keeps up a conſtant flame. Much of the perfection of this experiment depends on the nature, quantities, and figure of the materials made uſe of. If the wick be too large, it will ſupply a greater quantity of the fluid than can be well decompoſed. Its evaporation will therefore diminiſh the temperature, and conſequently the light, and afford a fuliginous column, which will paſs through the centre of the flame, and fly off in the form of ſmoke. The magnitude of the wick may, from time to time, in candles, be reduced, as to length, by ſnuffing; but this operation will not remedy the evils which ariſe from too great a diameter. If the oil be not ſuffi-

ciently

ciently combuſtible, the ignition will be but moderate, and the flame yellow; and the ſame effect will be produced if the air be not ſufficiently pure, or abundant. An experiment to this effect may be made by including the flame of a ſmall candle or lamp in a glaſs tube about one inch in diameter, ſtanding on the ſurface of a table. The air which paſſes between the glaſs and the table, will be ſufficient to maintain a very bright flame; but if a metallic covering, perforated with a hole of about a quarter of an inch diameter, be laid upon the upper orifice of the tube, the combuſtion will be ſo far impeded, that the flame will be perceptibly yellower. The hole may then be more or leſs cloſed at pleaſure by ſliding a ſmall piece of metal, for example a ſhilling, over it. The conſequence will be, that the flame will become more and more yellow, will at length emit ſmoke, and if the hole be entirely cloſed, extinction will follow.

The ſmell ariſing from the volatile parts which paſs off, not well conſumed, from a lamp or candle, muſt be different according to the nature of thoſe parts. This depends chiefly on the oil, but in ſome meaſure upon the wick. When a candle with a cotton wick is blown out, the ſmell is conſiderably more offenſive than if the wick be of linen, or of ruſh; but leſs offenſive than if the ſupply of the combuſtion had been oil. Whenever a candle or lamp is removed, the combuſtion is in ſome meaſure impeded by the ſtream of cold air againſt which it ſtrikes. Smoke is accordingly emitted from its anterior ſide, and the peculiar ſmell is perceived. From this imperfection, lamps are much leſs adapted to be carried from place to place than candles.

From the neceſſity of the acceſs of air there will be more light produced from a lamp with a number of ſmall wicks, than with one large one, or from a number of ſmall candles, than the ſame quantity of tallow uſed to make a ſingle large one. In the lamp of Argand, the wick conſiſts of a web of cloth in the form of a pipe or tube, the longitudinal fibres of which are thicker than the circular ones. This is paſſed by a ſuitable contrivance into a cylindrical cavity, which contains the oil, and there are other precautions in the conſtruction of the apparatus by which the oil is regularly ſupplied, the acceſs of air is duly permitted, as well within as without the circle formed by the upper edge of this cylindrical wick, and this edge can be raiſed or lowered at pleaſure. Hence the poſſeſſor has it in his power to regulate the ſurface of the wick, ſo that the greateſt flame conſiſtent with perfect combuſtion may be produced; and the ſteadineſs of the flame is ſecured by a glaſs ſhade or tube, which ſurrounds it, and in a certain degree accelerates the current of air.

In the illumination by candles, where the fuſed matter is contained in a cup or cavity of the matter not yet fuſed, it is of ſome conſequence whether the ſubſtance be fuſible at a high or low temperature. The difference between wax and tallow candles ariſes from this property. Wax being leſs fuſible will admit of a thinner wick, and needs no ſnuffing; but in a tallow candle, it is abſolutely neceſſary to have a large wick capable of taking up the tallow as it melts.

The difference of effect in illumination between a thick and a thin wick, cannot be better ſhewn than by remarking the appearances produced by both. When a candle with a thick wick is firſt lighted, and the wick ſnuffed ſhort, the flame is perfect and luminous, unleſs its diameter be very great; in which laſt caſe, there is an opake part in the middle where the combuſtion is impeded for want of air. As the wick becomes longer, the ſpace between its upper extremity and the apex of the flame is diminiſhed; and conſequently the oil which iſſues from that extremity, having a leſs ſpace of ignition to paſs through, is leſs completely burned,

burned, and paſſes off partly in ſmoke. This evil continues to increaſe, until at length the upper extremity of the wick projects beyond the flame, and forms a ſupport for an accumulation of ſoot, which is afforded by the imperfect combuſtion. A candle in this ſituation, affords ſcarcely one tenth of the light which the due combuſtion of its materials would produce; and tallow candles, on this account, require continual ſnuffing. But on the contrary, if we conſider the wax candle, we find, that as its wick lengthens, the light indeed becomes leſs, and the cup becomes filled with melted wax. The wick however, being thin and flexible, does not long occupy its place in the centre of the flame; neither does it, when there, enlarge the diameter of the flame, ſo as to prevent the acceſs of air to its internal part. When its length is too great for the vertical poſition, it bends on one ſide; and its extremity, coming into contact with the air, is burned to aſhes, excepting ſuch a portion as is defended by the continual afflux of melted wax, which is volatilized and completely burned by the ſurrounding flame. We ſee therefore, that the difficult fuſibility of wax renders it practicable to burn a large quantity of fluid by means of a ſmall wick; and that this ſmall wick, by turning on one ſide in conſequence of its flexibility, performs the operation of ſnuffing upon itſelf, in a much more accurate manner than it can ever be performed mechanically.

LIME. Is made by expoſing chalk or other native combinations of calcareous earth and fixed air, to ignition, in a furnace properly adapted for that purpoſe, called a lime-kiln. The heat muſt be of conſiderable intenſity, and continued twelve or fifteen hours. A leſs time will be ſufficient if the heat be greater, or a longer if it be more moderate. The effect of this proceſs is to drive off the fixed air and water, which compoſe about half the weight of ſuch ſtones. Calcareous earth thus treated, is ſaid to be in a cauſtic ſtate, from its diſpoſition to combine with and deſtroy the organization of animal ſubſtances, by forming a ſoap with their fat parts. As calcareous earth is infuſible by the heat of a furnace, there would be no danger from too violent a heat if the ſpecimens of chalk or lime-ſtone were pure; but as this is ſeldom the caſe, an extreme degree of heat produces a commencement of vitrification in the compound ſtone, and enables it to preſerve its ſolidity when attempted to be made into mortar. This is called over-burned lime.

If the calcination be perfectly accompliſhed, the quick lime will have a very ſtrong tendency to combine with water. When this fluid is thrown upon a maſs of quick lime, it becomes hot, cracks and ſplits with noiſe, emits boiling hot vapour, falls to pieces, and is in a very little time totally reduced to a fine powder. This experiment is even attended with light, if performed in the dark. Quick lime expoſed to the air attracts, in the courſe of time, a ſufficient quantity of water to pulverize it. It is then called lime ſlaked in the air. It reſumes very little fixed air by this expoſure.

The paſte of lime mixed with ſand to give it firmneſs, is well known for its utility in the art of building. It is diſpoſed to reſume its original ſtate and become ſtone again, by a long courſe of drying and re-abſorption of fixed air. The drying may be greatly accelerated by adding one quarter of the weight of mortar, of quick lime in powder, a very ſhort time before the mixture is uſed. This effect is ſimilar to what takes place in the uſe of the natural compound called plaſter of Paris, which conſiſts of gypſum, and a ſmall portion of uncombined lime. See EARTH CALCAREOUS.

LINEN FOSSIL. The fibrous amianthus. Its fibres being long, parallel, and

and in a certain degree flexible, afford the facility of making it into cloth, which is incombuſtible in the moderate heat of a fire; but may be fuſed, if the temperature be conſiderably raiſed. See ASBESTOS.

LINSEED. See OIL.

LIQUEFACTION. A chemical term not much uſed. In ſome inſtances it is ſynonymous with the word fuſion, in others, with the word deliqueſcence, and in others again, with the word ſolution. It may eaſily be imagined, therefore, that accurate writers will uſe thoſe terms reſpectively, becauſe more definite.

LIQUID AMBER. A reſinous juice which flows from a large tree (Liquidambar ſtyraciflua Lin.) growing in Virginia, Mexico, and other provinces in America. This juice is at firſt about the conſiſtence of turpentine, but by long keeping hardens into a reſin: it is of a yellow colour inclining to red, of a warm taſte, and a fragrant ſmell, not unlike that of ſtorax heightened with a little ambergris. It was formerly of great uſe as a perfume, but is at preſent a ſtranger to the ſhops.

LIQUOR OF FLINTS. The preparation of this liquor conſiſts in uniting, by fuſion, powdered flints or ſand with a ſufficient quantity of fixed alkali, ſo that a compound reſults from it, in which the properties of the alkali prevail, and particularly a total ſolubility in water. For this purpoſe, one part of ground flints or ſand is to be well mixed with three or four parts of fixed alkali. The mixture is to be put into a crucible, which ought to be very large, in proportion to the quantity of matter. The crucible is then to be placed in a forge or good melting furnace, and gradually heated.

When this mixture has acquired a certain heat, a conſiderable boiling and ſwelling are obſervable, occaſioned by the action of theſe two matters upon each other. To prevent the matter in this ſtate from flowing over the crucible, this ought to be large, and the fire gradually raiſed. A part only of the mixture may be put into the crucible at once; and when its effervescence is over, the reſt may be added at different times, taking care that each portion to be added be previouſly heated, to prevent exploſion from any moiſture which it might contain, when mixed with red-hot melted matter.

When the effervescence of all the mixture is over, it is to be kept in a good fuſion during a quarter of an hour, and is then to be poured upon a greaſed ſtone or plate of iron. The matter when cold is brittle, and ſeems vitrified. It is even tranſparent like glaſs, when the quantity of alkali is only double or nearly double the quantity of flints. It quickly and ſtrongly attracts moiſture from the air, and is entirely ſoluble in water, except a very ſmall portion of earthy matter. But a ſimilar earth is alſo ſeparated from pure conſiderably fixed alkali, during its ſolution in water.

The filtrated ſolution is at firſt clear, and limpid; but it afterwards becomes turbid, and forms an earthy ſediment, like that formed by ſolutions of fixed alkali, only the former ſeems more copious. This liquor has all the properties of liquid fixed alkali.

All theſe properties of alkaline ſalts, and particularly its total ſolubility in water, are cauſed by the quantity of fixed alkali which enters into this kind of vitrified matter. As compound bodies partake always of the properties of their component principles, and as the properties of the principle which predominates in the compoſition of any body, do alſo predominate in that body, we may perceive why the properties of the fixed alkali in the preſent combination ſhould be

more ſenſible than thoſe of the earthy matter, or flints. The alkali communicates to the earthy matter ſome of its ſtrong diſpoſition to unite with water. The flints are really kept diſſolved in water, and by this experiment they are conſequently reduced into a liquor, and hence it has been called the liquor of flints. If any acid be added to the liquor of flints, ſo as to ſaturate the alkali, the flint which was kept diſſolved in water by means of this alkali, will be now precipitated in the ſtate of a fine earth. Macquer mentions a ſingular fact from Pott, that the earthy precipitate will be entirely taken up, if a redundancy of acid be added: but this is contrary to the reſults of experiment by Bergman, Klaproth, and other eminent chemiſts; though an enquiry into the cauſe, which ſeems to have miſled Pott, Baumé, and others, certainly deſerves to be inveſtigated.

The glaſſes which contain too much alkaline ſalt in their compoſition, or which have not ſuſtained a fire long or ſtrong enough to unite the earth intimately with the fixed alkali, are partly ſoluble in acids, have ſometimes even an alkaline taſte, tarniſh, and moiſten in the air.

LIQUOR OF LIBAVIUS. See TIN.

LIQUORICE. The ſaccharine extract from liquorice is prepared by ſtrong decoction in water. It is prepared in the large way in Spain and ſome parts of Germany. The black colour ariſes from coal produced by the empyreuma towards the end of the proceſs. Neumann found that one ounce of the Spaniſh extract water diſſolved ſeven drachms two ſcruples, leaving a reſidue from which ſpirit extracted nothing. Rectified ſpirit firſt applied, diſſolved four drachms two ſcruples out of an ounce, which conſiſted of nearly the whole of the ſugar; for though water took up three drachms of the remainder, it was nearly taſteleſs.

LITHANTHRAX. Pit coal, or ſtone coal: a black, ſolid, compact, brittle, inflammable ſubſtance, of a moderate hardneſs, laminated texture, more or leſs ſhining, but in few ſpecimens capable of a good poliſh. None of the pit coals are fuſible, though ſome exhibit an imperfect degree of fuſibility. All the ſpecimens leave an earthy reſidue, when burned. It appears to conſiſt of aſphaltos, intimately mixed with a ſmall proportion of earth, moſtly of the argillaceous kind, ſeldom calcareous, and frequently intermixed with pyrites, either in nodules, or diffuſed in ſuch ſmall particles as ſcarcely to be diſcerned. According to Gerhard, quoted by Kirwan, ardent ſpirit extracts a red colour from it; cauſtic fixed alkali attacks the bituminous part, and fat oils act on and form a varniſh, at leaſt with ſome ſorts of it: a fixed alkali has never been found in it, nor any ſulphur, except it contained pyrites. See COAL.

LITHARGE. A calx of lead in an imperfect ſtate of vitrification. When ſilver is refined by cupellation with lead, this latter metal, which is ſcorified, and cauſes the ſcorification of the imperfect metals allayed with the ſilver, is transformed into a matter compoſed of ſmall ſemi-tranſparent ſhining plates, reſembling mica; which is litharge. Litharge is more or leſs white or red, according to the metals with which the ſilver was allayed. The white is called litharge of ſilver, and the red has been improperly called litharge of gold.

Litharge may be eaſily revived into lead; accordingly much of that which is produced by refining in the large way is reduced, by being melted upon burning coals. The part of it which is leaſt altered by mixture with other metals is thus reduced, and by this method good and ſaleable lead is obtained. The reſt of the litharge of theſe refineries is ſold and uſed for various purpoſes. Potters uſe much of it for glazing their ware. It is employed for the preparation of ſome

plaſters,

plaſters, and other external remedies; and alſo in painting, to render linſeed oil drying. Laſtly, it is added in the compoſition of ſome glaſſes, for it is very fuſible, and aſſiſts the fuſion of other ſubſtances. It has in general the ſame properties as the other calces of lead. All the litharge which is commonly ſold comes from refineries. The quantity formed there is more than ſufficient for the demand. See LEAD.

LITHOLOGY. The ſyſtematical arrangement of ſtones.

LITHOMARGA. See EARTH, FULLERS.

LITMUS. See HELIOTROPIUM.

LIVER OF ANTIMONY. A combination produced by detonating equal parts of crude antimony and nitre in a large crucible, and afterwards fuſing the maſs. The matter when cold is found to conſiſt of two diſtinct ſubſtances, ſeparable by the blow of a hammer. The upper matter is a ſaline ſcoria, compoſed of liver of ſulphur, vitriolated tartar, and a portion of antimony. The lower matter, or liver of antimony, is heavy, opake, compact, red, and brittle. Its component parts appear to be, the calx of antimony with ſulphur, and probably ſome of the alkali. There is reaſon to think that the calcination of the metal, the diſſipation of the ſulphur, and other circumſtances, may vary according to the management of the heat. But this ſcarcely deſerves to be enquired into, becauſe the compound is little uſed in medicine, and enters into none of the operations in philoſophical chemiſtry.

LIVER OF ARSENIC. See ARSENIC.

LIVER OF SULPHUR. The general name of ſulphureous hepar, or liver of ſulphur, has been given to a compound formed of ſulphur, with ſome alkaline ſubſtance. This compound conſidered in general is of a brown colour, reſembling that of the liver of animals; decompoſable by vital air; ſoluble in water, in which ſtate of ſolution it emits a fetid ſmell; precipitable in part by acids, which diſengage a peculiar elaſtic air, called HEPATIC AIR, which ſee. There are ſix kinds of liver of ſulphur produced by ponderous earth, magneſia, lime, and the three alkalis. The properties of each require to be particularly examined.

Pure ponderous earth does not appear to act ſtrongly on ſulphur; when theſe are boiled together with water, the liquid becomes in a ſmall degree hepatic; but it combines much more intimately in the dry way. When a mixture of eight parts of ponderous ſpar in powder with one part of charcoal, is ſtrongly heated in a crucible, a coherent maſs is obtained without fuſion, which readily diſſolves in hot water, and has the ſmell and every other character of a hepar. The ſolution is of a golden or orange colour. Fourcroy obſerved, that it cryſtallizes by cooling; it is then of a yellowiſh white. Expoſure to air decompoſes it, when it attracts moiſture, and becomes of deeper colour; ſulphur being precipitated, and ponderous ſpar regenerated. This liver of ſulphur gives out hepatic air on the addition of any acid. When the barytic hepar is precipitated by vitriolic acid, ſulphur, and ponderous ſpar fall down; if nitrous or marine acid be uſed, the barytic nitre or muriate remains in ſolution, and the ſulphur is depoſited alone.

Sulphur combines with pure magneſia, by the aſſiſtance of heat. Mild magneſia is commonly uſed for this purpoſe, becauſe more diffuſable in water. A pinch of magneſia, with a like maſs of the flowers of ſulphur, is put into a bottle with diſtilled water; this veſſel being perfectly filled, and well ſtopped, is expoſed to the heat of a water-bath for ſeveral hours. The water being then filtered, has a fetid ſmell of rotten eggs; ſtrongly colours metallic ſolutions, and

affords ſmall cryſtalline needles by ſpontaneous evaporation: in a word, it is a true magneſian liver of ſulphur; the magneſia being precipitable by fixed alkali, which has a ſtronger affinity with the ſulphur. As to the latter combuſtible ſubſtance, its preſence is eaſily aſcertained by the addition of an acid, which ſeparates it under the form of a white powder. Such was the kind of liver of ſulphur which M. Le Roi, phyſician at Montpellier, diſſolved in pure water, to imitate the hepatic mineral waters; but it is now known, that moſt of thoſe waters do not contain a true hepar, but are mineralized ſimply by impregnation with hepatic air.

Lime unites much more readily with ſulphur than the two ſubſtances before mentioned. If water be poured by a little at a time on a mixture of quick lime and flowers of ſulphur, the heat produced by the action of the water on the lime is ſufficient to promote the combination between it and the ſulphur. If more water be added, it becomes reddiſh, and emits a fetid or hepatic odour, being in fact a ſolution of ſulphur combined with lime. This hepar is not well prepared, but by the humid way, and it is often neceſſary to aſſiſt the combination by the application of a gentle heat, when the lime is not freſh. The compound is of a red colour; and the more cauſtic the lime, the deeper the red. When it is highly ſaturated, it depoſits, by cooling, a layer of ſmall needled cryſtals of an orange yellow, diſpoſed in tufts, which appeared to Fourcroy to conſiſt of flattened tetrahedral priſms, terminated by dihedral ſummits. Theſe cryſtals gradually loſe their colour by expoſure to air, and become white and opake, without any alteration in their form. Calcareous liver of ſulphur, moiſtened with a ſmall quantity of water, and diſtilled in the pneumatic apparatus, is partly decompoſed, and affords a large quantity of hepatic air: if it be evaporated to dryneſs, and calcined in an open crucible till it emits no more fumes, the reſidue conſiſts of ſelenite formed by the lime, and the vitriolic acid produced by the ſlow combuſtion of the ſulphur. Calcareous liver of ſulphur is quickly changed by expoſure to air, loſing its ſmell and colour, in proportion as the hepatic air is diſſipated. When diſſolved in a large quantity of water, the ſame alteration takes place, eſpecially when it is agitated, as Mr. Monnet obſerves, in his Treatiſe on Mineral Waters. Selenite remains after thoſe changes. When preſerved in bottles not quite full, it depoſits a black incruſtation on the glaſs, pellicles being at the ſame time formed, which fall to the bottom of the liquor. If the veſſel which contains it be well cloſed, it may be kept a long time unchanged. Calcareous liver of ſulphur is decompoſed by pure fixed alkalis, which have a ſtronger affinity than lime to the ſulphur. Acids precipitate the ſulphur in the form of a very ſubtle white powder, which has been called magiſtery of ſulphur. Fixed air effects this ſeparation as well as the others; but the action of neutral ſalts on calcareous liver of ſulphur is not known.

The two pure or cauſtic fixed alkalis have a very ſtrong action on ſulphur; they form the true hepars, which are leſs decompoſeable, and more permanent, than the others. The dry fixed cauſtic alkalis act on ſulphur when in the cold. With this intention, pure fixed alkali and ſulphur in powder muſt be triturated in a mortar; the moiſture of the air attracted by the alkali favours the re-action of the ſalt on the ſulphur. The mixture becomes ſoft, aſſumes a yellow colour, emits a fetid ſmell, and is converted into hepar; but when this hepar is diſſolved in water, the ſolution is of a pale yellow colour, and is found to contain a leſs quantity of ſulphur than the ſame hepar prepared by heat. The alkaline hepar is prepared in laboratories in two methods, by the dry, or by the moiſt way;

way; the firſt proceſs is performed by melting equal parts of dry lapis cauſticus and flowers of ſulphur in a crucible: as ſoon as the mixture is entirely melted, it is to be poured out on a marble ſlab, and appears when cool to be of a red brown colour, reſembling that of the liver of animals.

The two pure and cauſtic fixed alkalis act abſolutely in the ſame manner on liver of ſulphur, and are equally capable of diſſolving it by the dry way. Theſe combinations of cauſtic alkalis with ſulphur have hitherto been little attended to; liver of ſulphur having almoſt always been made with fixed alkalis, ſaturated with the fixed air. Yet Fourcroy obſerved two remarkable differences between theſe two kinds of hepar; thoſe made with the mild fixed alkalis require a longer time for their preparation, becauſe theſe ſalts are much leſs active. But the moſt important difference between the livers of ſulphur made with cauſtic or dry alkalis, in the dry way, is the comparative ſtate of their ſaturation. In fact, the firſt are brown, and more fetid when diſſolved, and the fixed air they afford is much more hepatic and inflammable than that of the ſecond. Theſe laſt are of a paler colour, often of a greeniſh grey; their ſmell is weaker, and their compoſition leſs durable. The mild fixed alkalis appear to preſerve their acid in their union with ſulphur, the air from theſe hepars not being inflammable till it has been deprived of its fixed air by waſhing it in lime-water. The cauſe of the differences between livers of ſulphur made with cauſtic alkalis, and with thoſe made with mild alkalis, conſiſts therefore in the preſence of the acid in the latter, which diminiſhes the effect of the alkali.

Solid alkaline liver of ſulphur, made with either of the fixed alkalis, is very fuſible, and, like calcareous liver of ſulphur, is decompoſed by heating in cloſe veſſels, after having been moiſtened with a ſmall quantity of water, in which circumſtance it gives out much hepatic air. It is capable of aſſuming a cryſtalline form when it becomes ſolid by fuſion; but this form has not yet been well deſcribed. While hot and dry it has a brown colour; in proportion as it cools and attracts the humidity of the air, it loſes its colour, and becomes paler. The contact of the air ſoon gives it a greeniſh yellow colour; after which it is rendered liquid by the moiſture it attracts, and is ſlowly decompoſed, ſo as to become converted at the end of a certain time into vitriolated tartar, or Glauber's ſalt. It diſſolves readily in water, immediately aſſuming a peculiar fetid ſmell; the hepatic air being formed by the re-action of the water: this ſolution is of a deep red colour, if the liver of ſulphur has been recently prepared, but otherwiſe a green. The livers of ſulphur prepared in the humid way, by heating a ſolution of either of the cauſtic fixed alkalis in water, with half their weight of powdered ſulphur, exhibit the ſame properties as the ſolution here mentioned. They may therefore be deſcribed both under the common name of alkaline liquid hepar.

The liquid alkaline liver of ſulphur, when very ſtrong, depoſits irregular needle-formed cryſtals by cooling. It is decompoſeable by the action of heat. When diſtilled in the pneumato-chymical apparatus, it affords hepatic air: expoſure to air likewiſe decompoſes it, ſo that it becomes turbid; pellicles are then formed, and ſulphur depoſited. Bergman and Scheele thought that this decompoſition is produced by the vital air of the atmoſphere; a ſmall quantity of liquid liver of ſulphur being placed under a glaſs veſſel with vital air, the latter is entirely abſorbed, and the hepar decompoſed. Mr. Scheele has even propoſed the application of this fact to eudiometrical purpoſes; and it is in fact one of the beſt methods of aſcertaining the purity of the air.

Earths and earthy ſalts have no action on alkaline liquid hepar when very pure; but if it has been prepared with a mild alkali, it becomes turbid by the addition of lime-water. Acids decompoſe it, by uniting with the alkali, and precipitating the ſulphur in the form of a very fine white powder, called magiſtery of ſulphur. Spirit of nitre poured on ſolid liver of ſulphur in fuſion, produces a detonation. All the acids decompoſe alkaline liver of ſulphur, and diſengage hepatic air. See AIR HEPATIC.

LIVER STONE. See LAPIS HEPATICUS.

LIXIVIAL. Thoſe ſalts are called lixivial which have been extracted by lixiviation, and theſe chiefly are fixed alkalis; which are therefore called lixivial ſalts. See ALKALI.

LIXIVIATION. The application of water to the fixed reſidues of bodies, or the purpoſe of extracting the ſaline part.

LIXIVIUM. A ſolution of reſidual ſalts, obtained by lixiviation.

LOADSTONE. An iron ore whoſe conſtitution has not yet been properly examined. It is of a dark or black lead colour, generally of conſiderable hardneſs, weight, and cloſeneſs of texture. It is ſuppoſed to contain much iron in the metallic ſtate, or nearly ſo. It attracts iron or ſteel filings, by which criterion it is eaſily known.

LOAM. A natural mixture of clay and ſand. The coloured clays and loams participate of iron; hence many of theſe melt in a ſtrong fire, without any addition; both clay itſelf, and mixtures of it with cryſtalline earths, being brought into fuſion by ferrugineous calces, though the fuſible mixtures of clay and calcareous earths are by the ſame ingredient prevented from melting. The bricks made from ſome loams, particularly the Windſor, are, when moderately burnt, remarkably free, ſo as to be eaſily rubbed ſmooth, cut, ſawed, grooved, &c. Hence their uſe in building furnaces, &c. They bear a conſiderably ſtrong fire, but have been frequently melted in a vehement one.

LODESTONE. A name given by the Corniſh miners to ſtones likewiſe called tin-ſtone. They conſiſt chiefly of ſtones or ſand of different kinds, through which calx of tin is inviſibly diſſeminated. They are heavy and of various colours, but blue, grey, black and brown are the commoneſt.

LOGWOOD. India, Jamaica*, or Campeachy wood has received thoſe names from the places where it grows moſt plentifully. It is very common at Jamaica, and on the eaſtern ſhore of the bay of Campeachy; and is found alſo at St. Croix, Martinico, and Granada.

The tree is called by Linnæus hæmatoxylum campechianum. It grows very high and large in a good ſoil: the bark is thin, ſmooth, and of a bright grey, or ſometimes yellowiſh: the trunk is ſtraight and prickly: the leaves ſomewhat reſemble thoſe of the bay tree in appearance, and alſo in their aromatic qualities, whence the tree has been called aromatic bay, or Indian bay: its ſeeds have been improperly called clove ſeeds, from their flavour, and in England are known by the name of Jamaica pepper, or all-ſpice.

Logwood is ſo heavy as to ſink in water, hard, compact, of a fine grain, capable of being poliſhed, and ſcarcely ſuſceptible of decay. Its predominant colour is red, tinged with orange, yellow, and black.

* In England; the name of Jamaica wood is commonly applied to the better ſpecies of mahogany, the inferior kind being brought from Honduras. Hamilton.

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For uſe, its juice as it is commonly called may be extracted by decoction with water. It yields its colour both to ſpirituous and watery menſtrua. Alcohol extracts it more readily and copiouſly than water. The colour of its dyes is a fine red, inclining a little to violet or purple, which is principally obſervable in its watery decoction. This, left to itſelf, becomes in time yellowiſh, and at length black. Acids turn it yellow: alkalis deepen its colour, and give it a purple or violet hue. Vitriolic, nitrous, and muriatic acids produce in it a ſmall quantity of a precipitate, which is ſome time in ſeparating, and its colour, with the vitriolic acid, is a dark red; with the nitrous, feuillemort; with the muriatic, a lighter red. The ſupernatant liquor is tranſparent, of a deep red colour with the vitriolic and muriatic acids, and yellowiſh with the nitrous. The acid of ſugar forms a light marone precipitate; the liquor remaining tranſparent, and of a yellowiſh red. The acetous acid acts nearly in the ſame manner, except that the colour of the precipitate is a little deeper. Tartar gives the ſame precipitate as vinegar, but the liquor remains turbid, and more inclined to yellow. Fixed alkali occaſions no precipitate, but changes the decoction to a deep violet, which afterwards becomes nearly brown. Alum produces a pretty copious precipitate, of a lightiſh violet colour; the liquor remaining violet, and nearly tranſparent. Alum and tartar occaſion a dark red precipitate in tolerable quantity; the liquor remaining tranſparent, and of a yellowiſh red. Vitriol of iron gives it inſtantly a blueiſh black colour, like that of ink; a pretty copious precipitate of the ſame colour is produced, and the liquor remains turbid a long while; but if it be ſufficiently diluted, and eſpecially if there be a ſmall exceſs of the vitriol, all the black matter is at length depoſited. Vitriol of copper produces a very copious precipitate, of a browner and leſs bright black than the preceding: the liquor remains tranſparent, and of a very deep browniſh or yellowiſh red. Sugar of lead inſtantly occaſions a black precipitate, with a ſlight reddiſh tinge; the liquor remaining tranſparent, and of the colour of very pale beer. Laſtly, tin diſſolved in aqua regia forms immediately a precipitate of a very fine violet or purple, almoſt prune de Monſieur: the ſupernatant liquor is very clear, and perfectly colourleſs.

Stuffs would take only a ſlight and fading colour from decoction of logwood, if they were not previouſly prepared with alum and tartar. A little alum is added alſo to the bath. By theſe means they acquire a pretty good violet.

A blue colour may be obtained from logwood, by mixing verdegris with the bath, and dipping the cloth till it has acquired the proper ſhade.

The great conſumption of logwood is for blacks, to which it gives a luſtre and velvety caſt, and for greys of certain ſhades. It is alſo of very extenſive uſe for different compound colours, which it would be difficult to obtain of equal beauty and variety, by means of drugs affording a more permanent dye.

Juice of logwood is frequently mixed with that of braſil, to render colours deeper; their proportion being varied according to the ſhade deſired.

Logwood is uſed for dyeing ſilk violet. For this the ſilk muſt be ſcoured, alumed, and waſhed; becauſe without aluming it would take only a reddiſh tinge, that would not ſtand wetting. To dye ſilk thus, it muſt be turned in a cold decoction of logwood, till it has acquired the proper colour: if the decoction were uſed hot, the colour would be in ſtripes and uneven.

Bergman has already obſerved, that a fine violet might be produced from logwood, by impregnating the ſilk with ſolution of tin. In fact, we may thus obtain, particularly by mixing logwood and braſil in various proportions,

a great number of fine ſhades, more or leſs inclined to red, from lilac to violet.

If decoction of logwood be ſubſtituted for that of braſil in the proceſs communicated by Mr. Brown, a fine violet colour will be obtained; and if the two be mixed, we ſhall have ſhades of puce colour, and prune de Monſieur, more or leſs inclining to red. See BRAZIL WOOD.

The remarks made on braſil are alſo applicable to logwood, the colouring matter of which exhibits ſimilar properties. Berthollet.

LUDUS HELMONTII. An indurated marle, compoſed of various pieces of a whitiſh brown colour, ſeparated into a great number of polygonous compartments, the boundaries of which are formed of matter of a lighter colour than the reſt. According to Bomare, the ludus ſtellatus Helmontii, found in the county of Kent, is covered with a kind of ſtriated ſelenite, reſembling the zeolite.

It is for the moſt part of a globoſe figure, ſeldom flat, but often convex on the outſide. And ſometimes with a concave ſurface.

According to Wallerius, the ludus Helmontii loſes by calcination about half of its weight; and, on being urged by fire, is melted into a black gloſſy ſlag. It effervesces ſtrongly with aqua fortis, and this ſolution is of a yellow colour. But what ſeems very extraordinary, by adding to it ſome oil of tartar per deliquium, bubbles are emitted, from which a great number of ſlender black threads, or filaments, are produced, ſticking like a cobweb to the ſides and bottom of the veſſel.

This ſtone is found quite ſeparate by itſelf, as well as various ſtalagmites, and cruſtaceous bodies, on the ſtrata of argillaceous earth, in various parts of Europe, chiefly in Lorrain, Italy, England (in the counties of Middleſex and Kent), and elſewhere.

LUMACHELLA. A conglutinated, calcareous ſtone, compoſed of ſhells and coral, united together by a cement of the ſame nature. When they have many colours, they are called marbles, and employed as ſuch. In the iſland of Gottland there is found one of this kind of one colour only, which on that account is not called marble, or uſed as ſuch.

LUNA. The alchymiſt's term for ſilver.

LUNA CORNEA. The combination of marine acid and ſilver. See SILVER.

LUNAR CAUSTIC. The nitre of ſilver, fuſed in a low heat. See SILVER.

LUTE. In many chemical operations, the veſſels muſt be covered with ſomething to preſerve them from the violence of the fire, from being broken or melted, and alſo to cloſe exactly their joinings to each other, to retain the ſubſtances which they contain, when they are volatile and reduced to vapour. For this purpoſe ſeveral matters are employed, called in general lutes.

The lutes with which glaſs and earthen ware retorts are covered, ought to be compoſed of nearly equal parts of coarſe ſand and refractory clay. Theſe matters are to be well mixed with water and a little hair, ſo as to form a liquid paſte, with which veſſels are to be covered, layer upon layer, till it is of the required thickneſs. See COATING.

The ſand mixed with the clay is neceſſary in this lute, to prevent the cracks which are occaſioned by the contracting of clay during its drying, which it always does when it is pure. The hair ſerves alſo to bind the parts of the lute, and to keep

keep it applied to the veſſel: for, notwithſtanding the ſand which is introduced into it, ſome cracks are always formed, which would occaſion pieces of it to fall off.

The lutes with which the joinings of veſſels are cloſed, are of different kinds, according to the nature of the operations to be made, and of the ſubſtances to be diſtilled in theſe veſſels.

When vapours of watery liquors, and ſuch as are not corroſive, are to be contained, it is ſufficient to ſurround the joining of the receiver to the noſe of the alembic, or of the retort, with ſlips of paper or of linen, covered with flour-paſte. In ſuch caſes alſo ſlips of wet bladder are very conveniently uſed.

When more penetrating and diſſolving vapours are to be contained, a lute is to be employed of quick-lime ſlaked in the air, and beaten into a liquid paſte with whites of eggs. This paſte is to be ſpread upon linen ſlips, which are to be applied exactly to the joining of the veſſels. This lute is very convenient, eaſily dries, becomes ſolid, and ſufficiently firm.

Laſtly, when ſaline, acid, and corroſive vapours are to be contained, we muſt then have recourſe to the lute called fat lute. This lute is made by forming into a paſte ſome dried clay finely powdered, ſifted through a ſilken ſearce, and moiſtened with water, and then by beating this paſte well in a mortar with boiled linſeed oil, that is, oil which has been rendered drying by litharge diſſolved in it, and fit for the uſe of painters. This lute eaſily takes and retains the form given to it. It is generally rolled into cylinders of a convenient ſize. Theſe are to be applied, by flattening them, to the joinings of the veſſels, which ought to be perfectly dry, becauſe the leaſt moiſture would prevent the lute from adhering. When the joinings are well cloſed with this fat lute, the whole is to be covered with ſlips of linen ſpread with lute of lime and whites of eggs. These ſlips are to be faſtened with pack-thread. The ſecond lute is neceſſary to keep on the fat lute, becauſe this latter remains ſoft, and does not become ſolid enough to ſtick on alone.

LYCOPODIUM. The fine duſt of lycopodium, or puff-ball, is called by ſome, on account of its great inflammability, vegetable ſulphur. The puff-ball is the ſeed-veſſel of a ſpecies of moſs named by Tournefort Muſcus ſquamoſus vulgaris repens clavatus; and the duſt is properly the ſeeds of the plant. There are ſundry other vegetables, as polypodies, ferns, corniferous trees, &c. whoſe ſeeds are like a yellow, impalpable farina, ſo ſubtle as to be blown away by the leaſt motion of air: it is this duſt which has given riſe to ſome reports of ſhowers of brimſtone.

The duſt of lycopodium, diffuſed or ſtrewed in the air, takes fire from a candle, and burns off like a flaſh of lightning, with a conſiderable noiſe. It is uſed in the London theatres. A quantity laid together upon burning coals does not flame, but ſmokes away with a fetid ſmell: burned in a red-hot crucible, it leaves a very ſmall proportion of a light cobweb-like matter. It does not, as ſome report, take fire from flint and ſteel, nor explode like gunpowder; nor does it ſeem to detonate more violently with nitre than other inflammable matters do. Olearius relates, that the Ruſſians employ much of it in fire-works, but does not inform us in what manner.

There is a curious experiment of taking a ſhilling from the bottom of a veſſel of water without wetting the hand. It is ſaid to be done by ſtrewing a ſmall quantity of the duſt of lycopodium on the ſurface of the water, which it ſo

ſtrongly repels, as to form a covering for the hand, and defend it from the contact of the water.

Neumann examined this ſubſtance. It appears to contain a reſinous matter, and an oily one of the expreſſible kind, intimately combined together, ſo as to be both extracted, at leaſt in part, by rectified ſpirit of wine: on inſpiſſating the tincture, the oil ſeparated, remained permanently fluid, and would not unite again even with the reſinous extract: it is remarkable that pure ſpirit would no longer touch this reſin any more than the oil. The quantity thus extracted from an ounce of the powder amounted only to a dram: water did not take up near ſo much; it was with great difficulty he obtained by water eight grains of extract from an ounce. Both the water and ſpirit aroſe in diſtillation unchanged.

By deſtructive diſtillation in an open fire, he gained a large proportion of empyreumatic oil, no leſs than two ounces and a half from four: this was preceded, not by an acid liquor, which moſt vegetables yield on the ſame treatment, but by an alkaline one: the black coal remaining in the bottom of the diſtilling veſſel weighed five drams.

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MACE, one of the exterior coverings of the nutmeg, is at firſt of a purpliſh red colour, which changes before it arrives among us to an orange yellow, and by long keeping grows paler and paler. Mace is a warm aromatic, like the nutmeg, accompanied with a degree of bitteriſhneſs; and like that ſpice alſo contains both an eſſential and expreſſible oil.

From ſixteen ounces of mace, Neumann obtained with rectified ſpirit four ounces and a half of extract, which, retained ſome of the expreſſible, and the more ponderous part of the eſſential oil, the lighter ariſing towards the end of the inſpiſſation, and impregnating the diſtilled ſpirit: from the reſiduum were obtained two ounces and a half of gummy extract, with five drams of eſſential oil, which aroſe during the inſpiſſation, and ſunk to the bottom of the diſtilled water: the reſiduum gave with rectified ſpirit three ounces of an oily extract, eight ounces and a half remaining undiſſolved. The watery extract has an unpleaſant ſomewhat ſaline taſte, which that of nutmegs has nothing of. On expreſſion, mace yields an oil leſs conſiſtent than that of nutmegs, and which is uſually brought from the Eaſt Indies in glaſs or porcelane veſſels.

MACERATION. The ſteeping of a body in a cold liquor. It does not differ from DIGESTION, excepting that the term is never uſed when the temperature of the maſs is raiſed beyond that of the ſurrounding air. It is obvious that maceration, or digeſtion without heat, muſt be uſed in all requiſite caſes wherein the fugitive nature of ſome of the component parts of the ſubject of examination,

or its diſpoſition to become changed by heat, renders the proceſs of digeſtion, aſſiſted by heat, unfavourable to the intended analyſis.

MADDER. The following article is chiefly extracted from Berthollet's Treatiſe on Dyeing. Madder, a ſubſtance very extenſively employed in dyeing, is the root of a plant which Linnæus divides into two ſpecies; the firſt, rubia tinctorum foliis ſenis; the ſecond, rubia peregrina foliis quaternis. Of the firſt there are two varieties, the cultivated madder and the wild madder, called alſo rubia ſylveſtris monſpeſſulana major.

Although madder will grow both in a ſtiff clayey ſoil, and in ſand, it ſucceeds better in a moderately rich, ſoft, and ſomewhat ſandy ſoil: it is cultivated in many of the provinces of France, in Alſace, Normandy, and Provence: the beſt of European growth is that which comes from Zealand.

There are various methods of cultivating and preparing madder, and many treatiſes have been written on the ſubject: that of M. Duhamel may be conſulted, but more particularly that of M. Le Pileur d'Apligny, publiſhed at the end of his Art of Dyeing Threads and Cotton Stuffs.

The madder prepared for dyeing is diſtinguiſhed into different ſorts: that obtained from the principal roots is called grape madder (garance grape); the non-grape is that which is produced from the ſtalks, which by being buried in the earth are transformed into roots, and are called layers (couchis): each of theſe kinds is ſub-divided into robée, mi-robée, non-robée, ſhort, or mull, (mûle).

When the madder roots are gathered, the layers are ſeparated from them, to form the non grape; and ſuch of the fibres of the roots as do not exceed a certain degree of thickneſs are added, as are alſo thoſe roots which are too thick, and which contain a great deal of heart or ligneous part: the beſt roots are about the thickneſs of a gooſe quill, or at moſt of one's little finger; they are ſemi-tranſparent, and of a reddiſh-colour; they have a ſtrong ſmell, and the bark is ſmooth.

When the madder is gathered and picked, it muſt be dried, in order to render it fit for grinding and being preſerved: in warm climates it is dried in the open air; in Holland, by means of ſtoves, which ſometimes communicate too great a degree of heat, and change its colour by an admixture of fuliginous particles. Hellot aſcribes the ſuperiority of the madder which comes from the Levant, to the circumſtance of its having been dried in the open air.

After the root has been dried, it muſt be ſhaken in a ſack, or lightly beaten on a wooden hurdle, after which it muſt be ſifted or winnowed. In this way the earth is ſeparated from it, and the billon is removed, a name by which the ſmall roots and their bark are diſtinguiſhed. After this, nothing remains but to reduce it to powder, which may be done by a vertical millſtone, or by peſtles, or even by a common ſnuff-mill.

All the parts of the madder cannot be powdered with equal facility; the outer bark and ligneous parts are more eaſily pounded than the parenchymatous parts. Advantage is taken of this circumſtance in order to ſeparate thoſe parts, as they do not all give the ſame colour; the outer bark, as well as the wood within, affords a yellowiſh colour, which ſpoils the red we wiſh to obtain. This ſeparation eſtabliſhed the diſtinction of madder into robée, mi-robée, and courte. After the firſt operation of the mill, the madder is paſſed through a ſieve, with a cover fitted to it, by which means, what is called the ſhort madder, which is intended for tan and mordoré colours, is obtained; the remainder is again ground

and ſifted, and thus the mi-robée is obtained; and a third operation affords the robée. The madder thus powdered is to be preſerved in a dry place, well packed in caſks, where from its natural unctuoſity it concretes into lumps.

Mr. Beckmann * agrees with Mr. Hellot in opinion, that the heat of ſtoves injures the colour of madder, and that it would be better to dry it in the air only, the effect of which might be promoted by various means. He finds that common ovens, immediately after the bread is taken out, may be uſed inſtead of the Dutch ſtoves, when artificial heat is to be employed. M. D'Ambourney † has made ſome intereſting experiments on madder; he thinks, that the freſh root may be uſed in dyeing, with as much advantage as the powdered. He obſerved that four pounds of the freſh are equal to one of the dried, although in the drying ſeven-eighths of its weight are loſt; the expence of ſtoving, packing, and ſifting is ſaved; and it is only neceſſary to take care that the roots be thoroughly waſhed in a current of water as ſoon as they are taken out of the ground; they are afterwards cut into pieces, and bruiſed by the vertical mill. In dyeing with the freſh roots, on account of the quantity of water they contain, we muſt take care not to put too much water into the bath. Mr. Beckmann ſubſcribes to M. D'Ambourney's opinion, though he has conſtantly made one obſervation which ſeems to contradict it, that madder is more fit for dyeing, after having been preſerved for two or three years, than when freſh.

In the neighbourhood of Smyrna, and in the iſland of Cyprus, a kind of madder is cultivated, which affords a more lively red than that raiſed in Europe; on which account, it is employed in the preparation of the Adrianople red. In the countries where it grows it is called chioeborza, and hazala, but it is commonly known by the name lizari. It is now cultivated in Provence, and Mr. Beckmann has raiſed it with great ſucceſs at Gottingen.

The red colouring matter of madder may be diſſolved in alcohol, and on evaporation, a reſiduum of a deep red is left. Fixed alkali forms in this ſolution a violet, the vitriolic acid a fawn-coloured, and the vitriolated tartar a fine red precipitate. Precipitates of various ſhades may be obtained by alum, nitre, chalk, ſugar of lead, and the marine ſalt of tin.

When madder is macerated in ſeveral portions of cold water ſucceſſively, the laſt receives only a fawn colour, which appears entirely different from the peculiar colouring particles of this ſubſtance, and reſembles that which is extracted from woods and other roots: this fawn-coloured ſubſtance does not perhaps belong to the pulp, but is peculiar in the ligneous and cortical parts.

After Berthollet had by repeated boiling exhauſted the madder of ſuch colouring parts as are ſoluble in water, it ſtill retained a deep colour, and alkali extracted from it much colouring ſubſtance: the reſiduum which ſtill remained coloured was very inconſiderable; ſo that the pulp appears to be entirely compoſed of colouring matter, a large part of which is not ſoluble in ſimple water.

Aerated muriatic acid, employed in ſufficient quantity to change an infuſion of madder from a red to a yellow colour, produces a ſmall quantity of a very pale yellow precipitate; and the ſupernatant liquor is tranſparent, retaining a greeniſh yellow colour, more or leſs deep according to the quantity and ſtrength of the aerated muriatic acid.

The quantity of this liquor required to deſtroy the colour of a decoction of

* Nov. Comment. Societ. Reg. Gotting. tom. viii.

† Déliber. & Mem. de la Société d'Agriculture de la Généralité de Rouen.

madder,

madder, is double what is neceſſary to deſtroy that of a decoction of an equal weight of braſil wood; which proves that the colouring particles of madder are much better calculated to reſiſt the influence of the air, than thoſe of braſil wood. They would be eaſily changed, however, if not rendered fixed, by mordants. On this ſubject, Berthollet relates ſome experiments made by the celebrated Mr. Watt upon the beſt Zealand madder, and communicated to him.

A. This madder is of a browniſh orange colour, and of the conſiſtence of a coarſe powder, poſſeſſing a ſlight degree of coheſion; it attracts moiſture, in which caſe it loſes its properties, ſo as to become unfit for the purpoſes of dyeing.

B. With water it affords an infuſion of a browniſh orange colour; its colour cannot be extracted without a copious addition of water. Margraff directs three quarts of water for two ounces of madder. Its colouring particles may be extracted either by hot or cold water; to the latter it appears to give a more beautiful colour; its decoction is browniſh.

C. When an infuſion or decoction of this drug is ſlowly evaporated in an open veſſel, a pellicle is formed on the ſurface, which gradually falls to the bottom; after which freſh pellicles are ſucceſſively formed until the evaporation is finiſhed.

D. The extract thus prepared is of a dark brown; it partly diſſolves in water, to which it communicates a lightiſh brown colour.

E. The infuſion ſet to digeſt for ſome days in an open veſſel, which ſhould be of ſuch a height that the liquor reduced to the form of vapour may fall back again, depoſits dark brown pellicles. The liquor remains of a browniſh colour, and the pellicles are ſoluble in water, but with difficulty.

F. Alum forms in the infuſion B a deep browniſh red precipitate, compoſed of pellicles, and the ſupernatant liquor is of a yellow colour inclining to brown.

G. Mixed alkalis precipitate from this laſt liquor a lake of a blood red colour, which has greater or leſs intenſity, according to the quantity of alum that has been diſſolved in it. In this way, a blood red lake may be obtained; but we cannot, by any means hitherto known, give it the brightneſs of cochineal lake: in oil it is tranſparent, but in water it is opake and without beauty.

H. If a ſuperabundant quantity of alkali be employed, the precipitate is redi ſſolved, and the liquor becomes red.

I. The lake precipitated by vegetable alkali is of a more beautiful colour than that by the mineral alkali.

K. Calcareous earth precipitates a more dark and brown coloured lake than alkalis, particularly if it forms lime water.

L. If a few drops of alkali are added to the water employed in making the infuſion B, the infuſion extracts many colouring particles of a deep red bordering on brown. 1ſt. Alum precipitates a deep brown lake from this infuſion. 2dly. Acids added in ſmall quantity change it to a yellowiſh colour, and in greater quantity render it a brown yellow, but they precipitate nothing from it. 3dly. This infuſion evaporated to dryneſs forms a gummy extract, which eaſily diſſolves in water.

M. If the infuſion B be made with water very ſlightly acidulated with a mineral acid, it is yellowiſh. 1ſt. This liquor by long digeſtion becomes of a greeniſh brown, and the yellow appears to be deſtroyed. 2dly. The addition of an alkali reſtores the red colour, and the infuſion then affords, on evaporation, an extract which readily diſſolves in water.

N. If mild magneſia be added to the water uſed for the infuſion B, the infuſion is of a clear blood red, and on evaporation forms a blood red extract, which

readily diſſolves in water. 1ſt. A ſolution of this extract, which is employed as a red ink, when expoſed to the light of the ſun becomes yellow. 2dly. Alum precipitates from this infuſion a ſmall quantity of an ill-coloured lake. 3dly. Alkalis give it a redder and more fixed colour.

O. If the infuſion be made with a ſolution of alum, it is of an orange yellow. This infuſion precipitated by an alkali, affords a lake reſembling that of F, but its colour is not ſo good.

P. A ſolution of ſugar of lead added to the infuſion B, forms a browniſh red precipitate. 1ſt. A ſolution of mercury in the nitrous acid, gives a purple brown precipitate. 2dly. A ſolution of vitriol of iron, a fine bright brown precipitate. 3dly. A ſolution of vitriol of zinc has not been tried. 4thly. A ſolution of vitriol of manganeſe, a purple brown precipitate. 5thly. A ſolution of iron in aqua-regia has not been tried.

Q. The infuſion B being mixed while hot with the infuſion of cochineal, a browniſh red precipitate, bordering on a deep purple, was formed, of difficult ſolubility in water; by continuing the digeſtion, a greater quantity of this precipitate appeared. 1ſt. A pattern ſoaked in the preparation which the linen printers uſe, having been dyed in this mixture, took a browniſh red colour; and after having been boiled in a ſolution of ſoap, the colour appeared pretty good. 2dly. The ſolution of ſoap became very red, but communicated a very indifferent colour to paper.

Wool would receive from madder, as has been already ſtated, only a periſhable colour, if its colouring particles were not fixed by a baſe which occaſions them to combine with the ſtuff more intimately, and which in ſome meaſure defends them from the deſtructive influence of the air. For this purpoſe, the woollen ſtuffs are firſt boiled for two or three hours with alum and tartar, after which they are left to drain; they are then ſlightly wrung and put into a linen bag, and carried into a cool place, where they are ſuffered to remain for ſome days.

The quantities of alum and tartar, as well as their proportions, vary much in different manufactories. Hellot recommends five ounces of alum and one ounce of tartar to each pound of wool; if the proportion of tartar be increaſed to a certain degree, inſtead of a red, a deep and durable cinnamon colour is produced, becauſe, as we have ſeen, acids have a tendency to give a yellow tinge to the colouring particles of madder. Mr. Poerner ſomewhat diminiſhes the proportion of tartar, he directs that it ſhould be only one ſeventh of the alum; Scheffer, on the contrary, directs that the quantity of tartar ſhould be double that of the alum; but Berthollet found that, by employing one half tartar, the colour ſenſibly bordered more on the cinnamon than when the proportion was only one fourth of the alum.

In dyeing with madder, the bath muſt not be permitted to boil, becauſe that degree of heat would diſſolve the fawn-coloured particles, which are leſs ſoluble than the red, and the colour would be different from that which we wiſh to obtain.

When the water is at a degree of heat which the hand can bear, Hellot directs us to throw in half a pound of the beſt grape madder for each pound of wool to be dyed, and to ſtir it well before the wool is put in, which muſt remain for an hour without boiling; but in order to be more certain of the dye, it may be boiled for four or five minutes towards the end of the operation. Mr. Beckmann adviſes the addition of a little alkali to the madder bath; Berthollet approves the plan in the dyeing of thread and cottons.

By

By this proceſs reds are obtained, which are never ſo beautiful as thoſe produced even by kermes, much leſs thoſe from lake and cochineal; but as they coſt but little, they are uſed for common low-priced ſtuffs. The madder reds are ſometimes roſed with archil and braſil wood, in order to render them more beautiful and more velvety; but the brightneſs given them in this way is not laſting.

The quantity of madder which Mr. Poerner employs, is only one third of the weight of the wool, and Scheffer adviſes only one fourth. Mr. Poerner ſays, that having added to the alum and tartar, a quantity of ſolution of tin of equal weight with the tartar, and, after two hours boiling, having let the cloth remain in the bath that had been left to cool for three or four days, he dyed it in the uſual way, and obtained a pleaſing red. He deſcribes another proceſs, in which, after having prepared the cloth by the common boiling, he dyed it in a bath but ſlightly heated with a larger quantity of madder, tartar, and ſolution of tin; he let the cloth remain twenty-four hours in the bath, and after it had become cold, he put it into another bath made with madder only, and there left it for twenty-four hours: in this way he obtained a pleaſing red, ſomewhat clearer than the common red, and bordering a little on a yellow. According to Scheffer, by boiling wool with a ſolution of tin, the quantity of which he does not mention, with one fourth of alum, and by dyeing with one fourth of madder, an orange red is obtained.

Bergmann ſays, that if, without boiling the wool, it be dyed with one part of a ſolution of tin, and two parts of madder, it acquires a cherry colour, which when expoſed to the air acquires a deeper tinge.

If wool be boiled for two hours with one fourth of vitriol of iron, then waſhed, and afterwards put into cold water with one fourth of madder, and then boiled for an hour, a coffee colour is produced. Bergmann adds, that if the wool has not been ſoaked, and if it be dyed with one part of vitriol of iron and two of madder, the brown obtained borders upon a red.

According to theſe chemiſts, by employing vitriol of copper as a mordant, we obtain from madder a clear brown bordering on yellow. A colour of the ſame kind will be produced, by dyeing the wool ſimply ſoaked in hot water, with one part of vitriol of copper and two of madder: if equal parts of theſe two ſubſtances be uſed, the yellow will be ſomewhat more obſcure, bordering on a green; in both theſe caſes, the colour does not become darker by expoſure to the air.

Berthollet employed a ſolution of tin in various ways, both in the preparation and in the maddering of cloth. He uſed different ſolutions of tin, and found that the tint was always more yellow or fawn-coloured, though ſometimes brighter than that obtained by the common proceſs.

Madder does not afford a colour ſufficiently bright for dyeing ſilk; but De la Folie has given us a proceſs for employing it for this purpoſe.

Half a pound of alum is to be diſſolved in each quart of hot water, to which two ounces of pot-aſh are to be added: after the effervеſcence has ceaſed, and the liquor has begun to grow clear, the ſilk muſt be ſoaked in it for two hours; it is then to be waſhed, and put into a madder bath. Silk dyed in this way becomes more beautiful by the ſoap proof *. Scheffer gives us a ſomewhat different proceſs; the ſilk is to be alumed in a ſolution of four ounces of alum with ſix drams of chalk for each pound of ſcoured ſilk; when a ſediment is formed, the ſolution

* Journal de Phyſique, tom. xiii. p. 66.

is

is to be decanted; and after having become quite cold, the ſilk is to be put into it, and to be left eighteen hours; it is then to be taken out and dried, after which it is to be dyed with an equal weight of madder, when it takes a pretty good, but rather dark red. Mr. Guliche alſo deſcribes a proceſs for dyeing ſilk with madder*; for one pound of ſilk he orders a bath of four ounces of alum, and one ounce of a ſolution of tin; the liquor is to be left to ſettle, when it is to be decanted, and the ſilk carefully ſoaked in it, and left for twelve hours; and after this preparation, it is to be immerſed in a bath containing half a pound of madder ſoftened by boiling with an infuſion of galls in white wine; this bath is to be kept moderately hot for an hour, after which it is to be made to boil for two minutes. When taken from the bath, the ſilk is to be waſhed in a ſtream of water, and dried in the ſun. Mr. Guliche compares the colour thus obtained, which is very permanent, to the Turkey red. If the galls are left out, the colour is clearer. A great degree of brightneſs may be communicated to the firſt of theſe, by afterwards paſſing it through a bath of braſil wood, to which one ounce of ſolution of tin has been added: the colour thus obtained, he ſays, is very beautiful and durable.

Madder is uſed for dyeing linen and cotton red, and even for giving them many other colours by means of different admixtures; it is the moſt uſeful of all the colouring ſubſtances employed in this kind of dyeing. It is proper to enter into a ſomewhat minute detail of the different means by which this kind of dye may be rendered more certain, more beautiful and varied. Thread does not ſo eaſily take a colour from madder as cotton, but the proceſſes which ſucceed beſt for the one are likewiſe preferable for the other.

The madder red of cotton is diſtinguiſhed into two kinds: one is called ſimple madder red; the other, which is much brighter, is called Turkey or Adrianople red, becauſe it comes from the Levant, and has ſeldom been equalled in brightneſs or durability by our artiſts.

Madder reds likewiſe differ very much in brightneſs and permanency according to the proceſſes employed. We are indebted to Mr. Vogler for ſome very intereſting experiments on this ſubject. He firſt conſiders the mordants, and afterwards the preparation of the madder bath †.

The firſt mordant he tried, conſiſted of a ſolution of three drams of Roman alum in fourteen ounces of water. Thread and cottons boiled for ſome minutes in this ſolution, and afterwards paſſed through the different madder baths, which will be hereafter deſcribed, took a ſlight poppy-coloured red. Our author obſerved in this, and many other experiments, that Roman alum was much better than common alum, and gave greater brightneſs to the colours. He always uſed yellowiſh thread and cotton, which he firſt leyed, then waſhed and dried.

The above proportion of alum appeared to him the beſt; yet though he repeated the aluming three times, he was not able to give the thread and cotton a good colour. The addition of the ſmalleſt quantity of any kind of acid rendered it paler; the addition of arſenic produced no effect; ſheep and cow-dung, and album grecum, added to the mordant, as alſo urine employed inſtead of water to diſſolve the alum, contributed ſomewhat, but not much, to ſtrengthen the colour. Common ſalt and ſal-ammoniac had more effect, but theſe ſalts rendered the colour more dull; lime-water acted very much in the ſame way. The

* Volſtandiges Farbe, &c. iv. band.

† Crell, Neueſte Entdeckungen, vol. xiii. An. de Chym. t. iv.

ſubſtances

ſubſtances which had the beſt effect were gum arabic, ſtarch, fenugreek ſeed, and above all, glue. The author ſays he has attempted to impregnate thread and cotton with fiſh oil, hogs lard, and olive oil, but without ſucceſs. The gaſtric juice and the ſerous part of the blood of animals act like the glue.

The thread and cotton may be ſoaked alternately in a ſolution of glue and a ſolution of alum, or the glue may be diſſolved with the alum, in the proportion of from one dram and a half to four drams, with the quantity of alum directed. It is neceſſary to chooſe fine glue. This ſubſtance uſed with alum produces a more ſaturated colour, but without alum the red is duſky.

The marine and nitrous ſalts of clay not only produce a more intenſe and durable red than alum, but the tint is pleaſanter, more eſpecially when the nitrous ſalt is employed. In general, marine ſalts render the colour darker, more ſaturated, and more durable. Corroſive ſublimate produces the ſame effect.

Having diſſolved in a ſtrong ley of pot-aſh, as much powdered white arſenic as it would take up with the aſſiſtance of heat, and mixed this ſolution, which had been diluted with two parts of water, with a ſaturated ſolution of alum, the mixture became turbid, and of the conſiſtence of jelly; it recovered its tranſparency on adding gradually a ſolution of alum.

Thread and cotton ſoaked for twelve hours in this mordant, when waſhed and dried received from madder a beautiful well ſaturated colour. Thread and cotton, which had been for ſix hours in aqua regia, and afterwards waſhed and dried, took from madder a more beautiful and durable colour than that which dyers obtain from annotta; ſome bad madder, by means of this mordant, afforded a yellowiſh brown, of an agreeable ſhade.

This colour may be changed into a poppy-coloured red, which may be compared with the moſt beautiful colours of this hue, obtained from braſil wood and cochineal, by firſt ſoaking the ſtuff in a ſolution of alum and common ſalt, and boiling it a ſecond time with madder.

Mr. Vogler macerated for a night three drams of pot-aſh with an equal quantity of common madder in a pound of water; he then applied a boiling heat, and put into it ſome thread and ſome cotton, and after half a quarter of an hour's boiling, he took it out, rinſed and dried it, then ſoaked it in a ſolution of alum and common ſalt, after which he paſſed it through a ſolution of glue, and at laſt dipped it in a madder bath; it took a fine full red.

If to the preparation of madder and pot-aſh annotta be added, the thread and cotton take in this bath a beautiful orange colour; it is thus that the dyers in many places prepare that colour, but it is not ſo durable as that above deſcribed.

If inſtead of pot-aſh Roman alum be employed, a colour is obtained which is at firſt weak, though more lively than with the pot-aſh, and on going on with the proceſs a fine full red is obtained.

By giving a weak madder colour to thread and cotton that have been alumed, by afterwards ſoaking them in a ſolution of alum and ſalt, impregnating them with glue, and dyeing them a ſecond time in a madder bath, they take a beautiful very lively red.

The red of thread and cotton coloured by two madderings was very much weakened by the nitrous, vitriolic, and muriatic acids, diluted with two parts of water, and became more or leſs pale and yellow. The action of the nitrous acid was the moſt powerful, and that of the muriatic the weakeſt; this laſt turned the colour brown. The vegetable acids have a much weaker action; a ſolution of

alum powerfully diſſolved the colour, rendered it clearer, and at the ſame time brighter; pot-aſh and lime-water have the property of extracting much of its colour, and changing it to a deep red.

Galls diſpoſe thread and cotton to receive the madder colour. Mr. Vogler's preparation for galling conſiſted of five drams of black galls, kept for twenty-four hours in a pound of water, which was then boiled for ten minutes, and ſometimes he added ſix drams of common ſalt. The galled thread and cotton, after having received the mordants of alum and ſalt, took with the madder a perfectly ſaturated colour, but which was of a dark red. Thread and cotton ſucceſſively impregnated with a ſolution of tin and glue, ſteeped in an infuſion of cochineal and galls, waſhed and dried, and afterwards impregnated with the alum and ſalt mordant, and laſt of all dyed in a madder bath, received an uncommonly beautiful colour, which was very bright and conſiderably durable. The mordant of alum and corroſive ſublimate, and that of alum and ſalt, gave a ſomewhat deeper colour.

Mr. Vogler was equally ſucceſsful, when inſtead of galls he uſed ſeveral other vegetable aſtringents, ſuch as the ground bark of the alder and oak, the powdered bark of walnut-tree root, flowers and bark of pomegranate, the leaves, bark and tops of the ſumach. He made many experiments with metallic and earthy ſalts, all of which, except the aluminous and the ſolution of tin, appeared to him to be but little adapted, or entirely hurtful in the dyeing of red: the principal reſults were as follow:

The ſolution of nitre of lead employed as a mordant, produced a very loaded dirty red inclining to brown. In general, ſolutions of lead uſed as mordants for thread and cotton, diſpoſe them abundantly to receive colours from all vegetable colouring ſubſtances, but they have always a dark and dirty appearance. Theſe mordants may be employed for brown or black colours; the bad brown juſt mentioned, for inſtance, will change to a perfect brown of a very beautiful ſhade, if paſſed through a mordant of alum and ſalt, and boiled a ſecond time with madder. Mr. Vogler obtained a very fine black, by galling thread and cotton impregnated with ſalt of lead, and then putting them into a ſolution of vitriol of copper, and boiling them in a bath of logwood.

Cobalt diſſolved in aqua regia produced a very pleaſant colour nearly reſembling a very ſaturated violet. A ſolution of vitriol of copper gave a bad lilac. Verdegris diſſolved in vinegar produced the ſame effect.

The nitrous ſolution of copper produced a much more beautiful and ſaturated colour.

Thread and cotton that have received the mordant of vitriol of copper or iron, take in the madder bath a dirty dull violet colour.

Mr. Vogler having added the alkaline ſolution of arſenic above mentioned, to a moderately ſaturated ſolution of vitriol of copper or iron, produced a turbid mixture which efferveſced, and he rendered it tranſparent by adding vitriol of iron. Thread and cotton impregnated with this preparation received a beautiful ſaturated puce colour, which penetrated them deeply.

The nitrous acid marine ſalts of iron produced a better effect than the vitriolic and acetous ſalts of the ſame metal. They afforded a beautiful well ſaturated violet colour. The alkaline ſolution of arſenic mixed with earthy and metallic ſalts, generally renders them better mordants for all colours. This likewiſe renders the effect of the mordants into which it enters more laſting, ſo that the ſtuff impregnated with it many years before, may be dyed without diſadvantage; a circumſtance

circumſtance we do not remark reſpecting any other mordant, excepting a ſolution of tin. Vitriol of zinc afforded a weaker violet than vitriol of copper. Vitriol of lime and calcareous nitre produced no effect. Vitriol of manganeſe diſcovered ſome though but little action. Mr. Vogler remarks, that it is always neceſſary to rinſe the cotton and thread when they come out of a mordant; if this precaution be neglected, a weak colour only is frequently obtained, where a ſtrong one was expected, becauſe the particles of the mordant diſperſed through the bath, combine with the colouring particles and are precipitated with them; this precaution is eſpecially neceſſary, when we dye with ſubſtances which do not contain much colouring matter.

Mr. Vogler prepares the madder bath in different ways. He put three drams of madder into from ſixteen to eighteen ounces of water; he macerated it for twenty-four hours, then boiled it for a quarter of an hour, introduced the thread and cotton, and boiled them for half a quarter of an hour; he afterwards waſhed them in two or three waters, and then dried them in the ſhade: he remarks, that the colour of the ſtuff is taken away and deſtroyed by long boiling.

Freſh urine ſubſtituted for water affords more laſting colours; but in ſummer it is apt to become very ſoon putrid, ſo as to render the infuſion incapable of giving the dye.

One dram of ſheep's dung, or album grecum, produced the ſame effect as the urine.

Three drams of common ſalt, or one dram of ſal ammoniac, produced a fuller but leſs bright colour. Vitriolated tartar and nitre had no effect.

Three drams of white ſugar afforded a more beautiful and ſaturated colour; on the addition of four drams of long pepper, it was found to have become more capable of reſiſting the nitrous acid.

One dram or one and a half of ſtarch or gum arabic thrown into the bath juſt as it begins to boil, and before the cotton is put in, gives a finer and more ſaturated colour; one dram of fenugreek ſeed produced very nearly the ſame effect.

If in the beginning of the digeſtion four drams of Spaniſh pepper are added, we obtain from the liquor colours that are more durable than the preceding, eſpecially if we afterwards add three drams of common ſalt.

From one ounce to one ounce and a half of glue, in the ſtate of jelly, thrown into the liquor as the ebullition commences, affords a particularly beautiful full colour; and the addition of three drams of common ſalt not only renders the colour more laſting, but preſerves the infuſion from becoming putrid.

The moſt beautiful colour of all, however, is obtained by mixing four drams of ox-gall with the decoction; but at the ſame time it muſt be obſerved, that this colour is more eaſily deſtroyed by the nitrous acid than any other.

All the madder baths, except thoſe prepared with urine, glue, and animal dung, may be preſerved for a long time without loſing their power. Mr. Vogler kept ſome till they became mouldy and fœtid, and yet they dyed very well; nay, he obſerves that they produced more durable colours, or, at leaſt, colours which reſiſted the action of the nitrous acid more powerfully.

On putting from thirty-ſix to forty grains of cryſtals of tartar into the bath juſt as the linen was thrown in, the colour produced was found capable of reſiſting the nitrous acid. The vitriolic, nitrous, and muriatic acids, in very ſmall quantity, produced the ſame effect; in too large a quantity, they weakened the colour and rendered it pale. One dram and a half of powdered alum made the colour

finer, but not more durable; twenty-four drams of corroſive ſublimate rendered it more obſcure, but more permanent. White arſenic employed in different proportions never occaſioned the leaſt change, though dyers frequently uſe it as well as orpiment, with a view of making the colour more durable.

In Mr. Vogler's experiments, cotton always took the colour better than thread; the difference however was not very great, when he employed linen or hempen cloth that had been a little worn, and that had become ſoft to the touch, and when its texture was looſe and the thread ſlightly twiſted.

M. Le Pileur d'Apligny gives a very minute deſcription of the proceſs employed at Rouen for dying cotton red; it is as follows:

The cotton muſt be ſcoured, galled with one part of galls to four of the cotton, after which it muſt be alumed with four ounces of Roman alum to one pound of cotton, and an equal weight of water; to the ſolution of alum, one twentieth part of a ſolution of ſoda, conſiſting of half a pound of ſoda to a quart of water, muſt be added.

Some uſe only half the quantity of ſoda, and one ſixth leſs of water, which they replace by a ſolution of tartar and arſenic. M. Le Pileur d'Apligny thinks theſe laſt ingredients counteract each other. We have ſeen by Mr. Vogler's experiments, that tartar uſed with the mordant weakens the colour, and that arſenic was only uſeful when combined with an alkali.

Others add ſugar of lead, or the marine ſolution of tin. M. Le Pileur d'Apligny adviſes the addition of ſome vinegar to the ſugar of lead, in order to prevent the precipitation which is formed, when it is diſſolved in water.

When the cotton is taken out of the mordant, it is ſlightly wrung with the pin and dried; the colour is more beautiful as the drying is ſlow. They generally dye only twenty pounds of cotton at a time; it is better to dye even only ten, becauſe when too great a number of hanks are wrought in the copper it is much more difficult to dye them equally.

A copper in which ten pounds of cotton are to be dyed, ſhould hold about two hundred and forty quarts of water, which muſt be heated; when almoſt too hot for the hand, ſix pounds and a quarter of good Dutch grape madder are to be added, and carefully diſperſed through the bath. When it is well mixed with it, the cotton, which has been previouſly put upon the ſticks and placed at the edge of the copper, is to be immerſed hank by hank. All the cotton being put into the bath, it is to be worked, the hanks on each of the ſticks being turned for three quarters of an hour, and the bath kept conſtantly at the ſame degree of heat without boiling. At the expiration of this time, the cotton is taken out and placed on the edges of the copper, a pint of the above ley of ſoda is to be added to the bath; the cotton is then to be returned into the bath, and boiled from twelve to fifteen minutes; laſtly, it is to be taken out and left to drain, wrung, waſhed in a ſtream of water, and wrung on the pin a ſecond time.

Two days afterwards, the cotton receives a ſecond maddering in the proportion of eight ounces to the pound, and is worked about as in the firſt maddering, with this difference, that no ley is added, and that well water is employed for the bath: this maddering being finiſhed, the cotton is left to cool, waſhed, wrung, and dried.

M. Le Pileur d'Apligny does not think this method of dyeing by two baths a good one, becauſe it requires more time and fuel, and becauſe the ſecond maddering cannot furniſh much dye, the ſalts of the mordant having been exhauſted by the firſt. He propoſed another method, in which he ſays ſeveral

dyers

dyers have already ſucceeded; it conſiſts in aluming the cotton twice, and then dyeing it by one bath only.

In order to render this red more lively, a quantity of warm water, ſufficient to moiſten the cotton, is put into a caldron or vat, into which about a pint of the ley is to be poured; the cotton is to be ſoaked in this bath, pound by pound, left there for a moment, taken out, wrung, and dried. According to M. Le Pileur d'Apligny, this operation is uſeleſs; for, as the red cotton is intended for making ſtuffs, from whence it is neceſſary to ſeparate the preparation when they are to be wrought, the colour of the cotton is at the ſame time rendered more lively, becauſe it is paſſed through warm water rendered more active by the addition of a little ley. When the ſtuffs are taken out of this water, they are waſhed in a ſtream, and ſpread upon the graſs, where the red brightens more than it would do by any other operation.

The red in printed ſtuffs is likewiſe produced by madder, but it muſt be fixed by a mordant. Mr. Wilſon deſcribes that which is uſed for this purpoſe, as follows: In four pounds of hot water (ſome employ lime water) three pounds of powdered alum, and one pound of ſaccharum ſaturni, are to be diſſolved; this ſolution is put into a veſſel ſufficiently large to allow of the effervеſcence which takes place, and two ounces of powdered chalk, two ounces of pot aſh, and two ounces of ſublimate, or corroſive ſublimate, are to be added. This mixture muſt be well ſtirred and ſuffered to ſettle; the clear liquor muſt then be decanted, or, which is better, filtered.

With this liquor, coloured with the decoction of braſil wood, they print, and paſs the ſtuff through hot water in which cows dung has been diffuſed, in order to take away the ſtarch or gum, uſed to give conſiſtence to the mordant; they then carefully waſh it, and put it into a madder bath. All the ſtuff becomes coloured, but that which has not been fixed by the mordant is deſtroyed, by alternately boiling with bran, and expoſure on the graſs.

Mr. Oberkamf uſes the ſame ingredients for the mordant, except that he does not put into it any corroſive ſublimate. We have ſeen by Mr. Vogler's experiments, that that metallic ſalt rendered the colour of the madder more durable, and at the ſame time deeper.

The reader may here recollect, that alum is decompoſed by ſugar of lead, and that there reſults from the decompoſition an acetite of alumine, while the lead combined with the ſulphuric acid forms an inſoluble ſalt, which remains in the ſediment. The alkali and the chalk ſerve to take up the ſuperabundant acid, which would weaken the colour of the madder, and give it a yellow tinge.

Mr. Wilſon directs the uſe of this mordant, which is known by the name of printers mordant, and which is the ſame which Mr. Watt refers to in the experiments above mentioned, relative to the dying cotton red: according to his proceſs, it muſt be galled, dried, impregnated with the mordant, diluted with hot water, dried a ſecond time, maddered, waſhed, and dried again.

The Adrianople red poſſeſſes a degree of brightneſs, which it is difficult for us to approach by any of the proceſſes hitherto mentioned; it has likewiſe the property of reſiſting much more powerfully the action of different re-actives, ſuch as alkalis, alum, ſoap, and acids. Mr. Vogler confeſſes that, by his numerous proceſſes, he has not been able to obtain a red of a degree of permanency equal to that of the Adrianople red, though he has much excelled in this reſpect the falſe Adrianople reds, uſed for Siameſe (ſiamoiſes) and other ſtuffs. It is neceſſary to remark, that ſoap ſuds weaken and deſtroy the moſt durable madder colours,

even

even that of the Adrianople cotton: hence it appears, that we ought as much as poſſible to be ſparing in the uſe of ſoap, in the waſhing of thread and cotton of this colour. The only difference between the true and falſe Adrianople red is this, that the one reſiſts theſe influences much longer than the other. Aqua fortis, or dilute nitrous acid, is according to Mr. Vogler the beſt and moſt expeditious teſt, for diſtinguiſhing the true Adrianople red from the falſe. If we immerſe a thread of the latter dye in it, it ſoon becomes pale, and in leſs than a quarter of an hour white; while the true Adrianople red will remain in it for an hour without any alteration, and indeed never entirely loſes its colour, which acquires an orange hue.

The Adrianople red, which for a long time came to us by our Levant trade only, excited the induſtry of our artiſts; but their attempts were for a long time fruitleſs, or their ſucceſs confined to a very few manufactories. The Abbé Mazéas publiſhed ſome experiments which threw conſiderable light on this kind of dye; and the French Government, from the information it received, publiſhed in 1765, an inſtruction under the title of, A Memoir containing the Proceſs for Dyeing Spun Cotton of the ſame Scarlet Red as that of the Adrianople Cotton. We find the ſame deſcription in M. Le Pileur d'Apligny's treatiſe, but the proceſs has not ſucceeded completely; the fault ſeems principally to have conſiſted in making the alkaline ſolution too ſtrong. The alterations made in different manufactories, with more or leſs ſucceſs, have been kept ſecret. For the following deſcription, Berthollet was indebted to Mr. Clerc, who has the management of a manufactory at Vaudreuil, and who ſent him a pattern of his cotton, which was dyed of a beautiful and durable red.

Proceſs for the Adrianople or Turkey Red.

When a hundred pounds of cotton are to be dyed, we muſt begin by ſcouring it well. This operation conſiſts in boiling the cotton in a ley of ſoda, marking one degree of the areometer, to which is commonly added the remainder of the bath which has been employed for paſſing the cottons through, for the white preparation (en l'apprêt blanc), which is called ſickiou.

In order to ſcour the cotton properly, and prevent it from entangling, a cord is paſſed through three hanks (the hank is compoſed of four knots (pentes), each of which weighs a quarter of a pound, making the hank equal to a pound), and it is thrown into the ley when it begins to boil; it is carefully immerſed, that it may not be ſcorched by the upper part of the caldron, which ſhould contain about one hundred and fifty gallons of water for one hundred pounds of cotton; the cotton is completely ſcoured when it ſinks of itſelf in the caldron; it is then taken out, and waſhed knot by knot in the river, wrung, and hung out to dry.

Second Operation; Bath with Dung.

A hundred pounds of Alicant ſoda (barilla) in coarſe powder are put into a tub with a hole near its bottom, to allow the water to run into another tub placed under it; ſeventy-five gallons of lixivial water are poured on the ſoda in the upper tub: when the water which has run into the lower one marks two degrees of the ſoap-makers areometer, it is proper for the bath with dung, which is made in the following manner:

Twenty-five or thirty pounds of ſheep dung are mixed with the above ley in a large earthen veſſel, and ſtirred with a wooden peſtle, then paſſed through a hair ſieve placed over the vat in which the bath is to be prepared; twelve pounds

and a half of Provence oil are then poured into the vat, and kept conſtantly ſtirring with a rake, that it may be perfectly mixed with the ley and the dung; the ſoda ley is poured upon it; nine buckets of water (each equal to four gallons) are commonly required for a hundred pounds of cotton. The bath being thus prepared, is in a proper ſtate to receive the cotton. For this purpoſe, ſome of the bath is taken in a wooden bowl, and poured into an earthen pan ſet in brick-work at a proper height for working. A hank of cotton is taken and well wrought with the hands; it is frequently taken up and turned in the pan, and then hung upon a wooden hook fixed to the wall; it is ſlightly wrung out, and thrown upon a table; and the ſame operation is repeated with each hank. The table upon which the cotton is thrown ought to be raiſed eight or ten inches from the ground. A workman takes a hank in each hand, and ſtrikes it on the table to ſtretch the threads; he turns it three times, and then makes a ſmall twiſt to form a head for the hank, and lays it upon the table; not more than three hanks ſhould be placed one upon another, as too great a weight would ſqueeze the bath out of the under hanks. The cotton ought to remain ten or twelve hours on the table, and then be hung out to dry.

Third Operation; Bath with Oil, or White Bath.

Ley of ſoda alſo at two degrees of the areometer is taken; and after the vat in which the bath with dung was made has been well cleaned, twelve pounds and a half of olive oil are put into it, and the ley of ſoda added, while it is kept conſtantly ſtirred with a rake, in order to mix the oil completely. This bath ought to reſemble thick milk; and that it may be good, it is neceſſary that the oil ſhould not riſe to the ſurface: ſome of this bath is then put into the pan, and the cotton dipped hank by hank, as in the former operation; it is thrown on the table, and beat upon it, which is called crêper; it is left there till the next day, and then hung out to dry. For this bath about eight buckets of ley are required.

Fourth Operation; firſt Salt.

Freſh ſoda is added to the remainder of that firſt put into the tub, if the water poured upon it has not attained three degrees. For this operation, eight buckets of ley are poured into the vat upon the remains of the white bath, and the cotton is paſſed through it in the ſame manner as before. This operation is called giving it the firſt ſalt (donner le premier ſel); the ley being at three degrees.

Fifth Operation; ſecond Salt.

The cotton is paſſed through a ley of ſoda at four degrees, the working being conducted as before deſcribed.

Sixth Operation; third Salt.

The cotton is paſſed through a ley of ſoda at five degrees.

Seventh Operation; fourth Salt.

The cotton is paſſed through a ley of ſoda at ſix degrees, the ſame precautions being obſerved, and then carried out to be dried on very ſmooth poles; when dry, it is taken to the river to be waſhed in the following manner.

Eighth Operation.

The cotton muſt be firſt ſoaked in the water, then taken out and put upon the horſe (bayard) to drain; water is repeatedly thrown on it, that it may be well ſoaked, and an hour after it is waſhed knot by knot, to free it completely from the

the oil, which is abſolutely neceſſary to its taking the galling well; it is then wrung with the jack and pin, and ſtretched upon the poles to dry: the cotton when thus waſhed ought to be of a beautiful white.

Ninth Operation; galling.

For the galling, we muſt chooſe good galls in ſorts (a term employed in commerce, to denote black and white galls mixed together in equal quantities), and having bruiſed them, put for each hundred pounds of cotton, twelve pounds and a half into a copper, and boil them in ſix buckets of clear river water. Three hours are generally required to boil them ſufficiently; we perceive, that this is accompliſhed when they break between the fingers like bouille; three buckets of cold water are then added, and the whole paſſed through a very cloſe hair ſieve, ſqueezing with the hand what has not paſſed through, in order to ſeparate all the reſinous particles. When the water has ſettled and become clear, the galling is to be performed in the following manner:

Nine or ten quarts of the galling are poured into an earthen pan ſet in the wall at a height convenient for working, and the cotton is dipped in it by ſeparate hanks, working it well with the hands; it is then wrung with the pin, and carried out to be dried as faſt as it is dipped; a precaution eſſentially neceſſary to prevent the cotton from growing black.

When the cotton is thoroughly dried, we proceed to the aluming, in the following manner:

Tenth Operation; aluming.

The copper in which the decoction of galls was made being well cleaned, eight buckets of river water and eighteen pounds of Roman alum are put into it, and the alum diſſolved without boiling: when the ſolution is complete, half a bucket of ſoda ley at four degrees of the areometer is added, and the cotton then wrought in it, hank by hank, as in the galling; it is then ſpread out to dry, and afterwards waſhed from the alum as follows:

Eleventh Operation; waſhing from the Alum.

Having left the cotton to ſoak and drain for an hour upon the horſe, each hank is waſhed ſeparately three times, wrung with a pin, and carried to the tenter ground.

Twelfth Operation (remonter ſur Galle).

This operation conſiſts in a repetition of the former ones. A white bath is prepared ſimilar to that deſcribed in article 3; twelve pounds and a half of good Provence oil are put into a vat, and eight buckets of ley, at two degrees of the ſoap-makers areometer, added to it; and the bath being well ſtirred, the cotton is dipped in the manner deſcribed in article 3.

Thirteenth Operation; firſt Salt.

The cotton, after being well dried, is dipped in a ley at three degrees.

Fourteenth Operation; ſecond Salt.

After the cotton has been well dried, it is dipped in a ley at four degrees.

Fifteenth Operation; third Salt.

When the cotton is again dry, it is dipped in a ley at five degrees, and this concludes the dips: after being dried, it is waſhed, galled, and alumed, with the ſame proportions, and attention to the ſame circumſtances as in articles 9, 10, and 11. The cotton has now received all the preparations neceſſary for taking

taking the dye, and ought to be of the colour of the bark of a tree. A very eſſential circumſtance to be attended to, is, never to dip the cotton till it is perfectly dry, otherwiſe we run the riſk of rendering the colour ſpotted. When the cotton is hung out upon the poles, it muſt be frequently ſhaken and turned to make it dry uniformly.

Sixteenth Operation; the dyeing.

A copper of an oblong ſquare form is generally employed, which ought to be capable of holding about one hundred gallons, in which quantity twenty-five pounds of cotton may be dyed at once. The proceſs for dyeing is begun by filling the copper with water within four or five inches of the brim, and pouring in a pailful of bullock's blood, or, what is ſtill better when it can be procured, ſheep's blood (this is equal to about five gallons), and then adding the lizary. When we wiſh to obtain a fine bright colour, which penetrates, and has a good body, we commonly mix ſeveral kinds of lizary together, as one pound and a half of lizary of Provence, half a pound of lizary of Cyprus; or, if theſe cannot be had, a pound of that of Provence, with as much of the lizary from Tripoli or Smyrna, allowing always two pounds for one of cotton. When the lizary is in the copper, it is ſtirred with a rake, to break the clods or lumps; and when the bath is warm, the cotton is put in on ſkein ſticks, two hanks commonly on each; care muſt be taken to immerſe it properly, and to turn the cotton on the ſkein ſticks, by means of a pointed ſtick paſſed along them within the hanks. This proceſs is continued for an hour; and when the copper begins to boil, the cotton is taken off the ſkein ſticks, and immerſed in it, each hank being ſuſpended by means of a cord paſſed through it, to ſticks ſupported over the copper. The cotton ought to boil about an hour, in order to extract all the colouring matter from the madder. There is alſo a method of diſcovering when the colour is extracted, by the formation of a white froth on the copper. It is now taken out, and waſhed knot by knot at the river, wrung with the pin, and dried.

Seventeenth Operation; brightening.

Soda ley at two degrees is poured into the copper uſed for ſcouring, which ſhould hold a hundred and fifty gallons of water, and it is then filled within ten or twelve inches of the brim; four or five pounds of olive oil are then added, and ſix pounds of white Marſeilles ſoap cut very ſmall; it is kept ſtirring until the ſoap is diſſolved; and when the copper begins to boil, the cotton is put in, a cord being previouſly paſſed through it to prevent its being entangled: the copper is then covered up, and ſtopped with rags, loaded and made to boil gently for four or five hours: the cover being now taken off, the cotton ſhould appear finiſhed, and of a beautiful red. The cotton muſt not be taken out of the copper for ten or twelve hours, becauſe it improves in the bath, and acquires a much greater degree of brightneſs.

It muſt be well waſhed knot by knot, and dried, and the operation is complete.

Berthollet uſed to give his cottons a dip after they were quite dry; he made a ſolution of tin in aqua fortis, taking for a hundred pounds of cotton three or four pounds of aqua fortis at twenty-ſix degrees*, to which he added an ounce of ſal ammoniac for each pound, and then diſſolved in it ſix ounces of fine tin in grains; he added to the bath a pound and a half of mineral cryſtal; he then

* To diſtilled water as 1220 to 1000. Hamilton.

diluted the mixture with eight buckets of water, and dipped his cotton, which muſt then be waſhed; this dip gives the cotton a very fine fire (feu).

N. B. Only the reſidua of the firſt preparations are to be put into the ſickiou; thoſe which remain after the cotton has been galled are of no uſe, and muſt be thrown away.

Mr. Gren has publiſhed ſome experiments which throw a great d al of light on the theory of the Adrianople red *. He took two ounces of ſpun cotton, on which he poured freſh oil, and left it to ſoak for fifteen days, taking care to work the cotton well with it from time to time; he then ſqueezed out the oil as much as poſſible, and put the cotton into a boiling ſolution of barilla. After boiling it for half an hour, he poured out the ley, which had a milky appearance, and ſupplied its place with freſh urine, in which he boiled the cotton for a quarter of an hour; but he has aſcertained, that water may be ſubſtituted for the urine. He made a decoction with half an ounce of alum and two drams of ſumach, and put the cotton which had been well waſhed into it while boiling hot, and kept up the ebullition for an hour: after which he let it cool, and kept the cotton in it twelve hours: when taken out of this bath, it was dried in the ſhade, waſhed in cold water, and dyed with a decoction of half an ounce of madder; he choſe whole roots of madder the moſt ſlender he could find, cut them into ſmall pieces, and pounded them. He left the cotton to grow cold in the bath. When waſhed it ſhewed a very fine colour, which differed from the true Turkey red cotton only in luſtre, which it did not poſſeſs in ſo high a degree, but it ſuſtained the ſame proofs: thus it retained its colour after being waſhed in boiling water: the brightneſs of the colour was increaſed by waſhing in a cold ley of aſhes; vinegar did not change it; expoſure to the ſun and air for three weeks produced no ſenſible alteration in it.

Ground madder of a middling quality produced, under ſimilar treatment, a dirty brown colour without any brightneſs; but Zealand madder of a good quality produced a colour ſimilar to the former.

The addition of fixed alkali, even in ſmall quantity, to the decoction, produced a deeper colour. The addition of ſolution of tin gave the colour a more pleaſing hue.

Mr. Gren obtained only a bad colour, which ſimple waſhing diſcharged, when he uſed pure or cauſtic pot-aſh inſtead of ſoda; but carbonat of pot-aſh ſucceeded as well as ſoda, when care was taken to ſqueeze out the oil from the cotton previous to its being put into the ſolution of the ſalt: if the oil was not ſqueezed out, the colour was but indifferent: whence he infers, that the alkali ought not to be ſo cauſtic as to deprive the cotton entirely of the oil, while at the ſame time it ought to poſſeſs ſufficient activity not to allow it to retain too much. Theſe experiments alſo evinced, that in order to produce a red ſimilar to that of Adrianople, it was neceſſary to chooſe the beſt kind of madder, and to prefer the whole roots, rejecting thoſe which are too old, too woody, or rotten. When he employed different kinds of the ground madder, he moſt commonly obtained a dark brown colour inſtead of a red, notwithſtanding all the attention he could employ in the coction.

Berthollet, after having repeated the proceſs of Mr. Gren, and a great part of the numerous and intereſting experiments of Mr. Vogler, gives the following account of ſome others of his own.

* Crell, Neueſte Entdeckungen, vol. iii.

The acetite of alumine, formed by the mixture of alum and the acetite of lead or ſalt of ſaturn, proved to be a better mordant than alum for fixing the colour of madder, and was ſtill more efficacious when it contained an exceſs of acid, as it is prepared for the printing of linens, and as Mr. Wilſon directs.

Alum ſaturated with pot-aſh to ſuch a degree as to afford a ſlight ſediment, was alſo a much more efficacious mordant than alum, probably for the ſame reaſon. Solution of arſenic in pot-aſh produced a ſimilar effect, and even ſeemed to be ſuperior.

Galling renders the colour more fixed, and appears to darken it a little; yet galling is employed in the Adrianople proceſs. Galls cannot be mixed with madder, becauſe they prevent the extraction of its colouring part. Berthollet always began his proceſſes by galling, after having leyed the cotton.

Leying renders the cotton more diſpoſed to become ſaturated with colour.

Berthollet made the ſame obſervation as Mr. Vogler, that mucilages and gums render the colour more fixed, but that glue in particular produces this effect: it combines with the alumine and the cotton, and thus imparts to the cotton the property of animal ſubſtances.

Complete exſiccation between each of the proceſſes is very uſeful: when the water is expelled, its attraction no longer oppoſes the combination or decompoſition of the mordant to which it proved an obſtacle. It appeared to Berthollet a matter of indifference whether the exſiccation was quick or ſlow, provided however it was not too rapid, becauſe of the cryſtallizable ſalts, the alum for example, for then, the ſolution exſudes before it is decompoſed, and cryſtallizes on the ſurface; in which caſe the dyers ſay that it has run. This is probably the reaſon for directing that the exſiccations ſhould be conducted in the ſhade, and not in the ſun.

Berthollet found that long maceration and long continued boilings with the mordant were uſeleſs, and that it was ſufficient if the cotton was well impregnated with the mordant: it appeared to him, for example, that no greater effect is produced by repeating the aluming two or three times ſucceſſively, than by one operation properly conducted.

If only the ſaturation and permanency of the colour were attended to, we ſhould from the experiments of Berthollet begin by leying the cotton, galling, drying, and ſoaking it in the mordant compoſed of alum and the alkaline ſolution of arſenic, or in the ſaturated acetite of alumine; we ſhould then dry it, ſoak it in a ſolution of glue, dry, and wet it, that it may not take the colour unequally, and laſtly, dye it in a madder bath containing glue. If we add common ſalt to one of the firſt preparations, the dye is ſtill ſtronger (plus forte); but the colour obtained in this manner, and by ſimilar proceſſes, is browner and much leſs bright than the Adrianople red.

Of the two proceſſes by means of which Berthollet came neareſt the Adrianople red, without uſing a conſiſtent oil, the one was by employing as mordant, a ſolution in the nitrous acid of the precipitate from alum by common pot-aſh; the other was by adding calx of tin to the madder bath. By this laſt proceſs, Berthollet obtained a red which might eaſily be taken for that of Adrianople.

He repeated the proceſs of Mr. Gren with ſucceſs, ſubſtituting galls for the ſumach; but the colour which he obtained, and which came very near the Adrianople red, withſtood the action of leys, ſoap, and the air, leſs powerfully.

We have ſeen that Mr. Vogler had not ſucceeded by impregnating the cotton with oil; and yet without a greaſy ſubſtance, we cannot obtain a colour like the Adrianople red. The inteſtinal liquor of ſheep, employed in the Adrianople proceſs under the name of ſickiou, ſeems to act by means of the greaſe which it contains, and by a ſubſtance analogous to the ſeroſity and gluten found in all animal ſubſtances.

Mr. Pallas relates in the Peterſburgh Journal for 1776, that the Armenians, whom the troubles in Perſia obliged to retire to Aſtracan, dye Turkey red by alternately impregnating the cotton with fiſh oil, and drying it, for ſeven days; that they have obſerved that other oils do not ſucceed; and that they do not even uſe the oil of all fiſh indiſcriminately, but chooſe that which becomes milky upon being mixed with an alkaline ſolution. After theſe repeated impregnations and exſiccations, they waſh the cotton and dry it: they then give it an aſtringent bath to which a little alum is added; they dye it in a madder bath with which calves blood has been mixed; finally, they digeſt it for twenty-four hours in a ſolution of ſoda. It would ſeem that Mr. Vogler had not remarked, that the cotton ſhould be deprived of the oil only to a certain degree by means of the ley.

The following obſervations prove that, in the Adrianople red, the cotton has retained a little of the oil. A ſkein of cotton having been ſoaked in ſoap ſuds, and wrung ſlightly, was dried, and then immerſed in a mordant of alum ſaturated with pot-aſh, afterwards dried, and dyed; it had only a well ſaturated madder colour: after two minutes boiling in weak ſoap-ſuds, it came out with the ſhade of Adrianople red: its durability was not examined.

If cotton dyed with madder in any way be boiled for ſome minutes in ſoap ſuds, it acquires a roſe colour (roſé); if it be then ſqueezed, a greaſy matter is preſſed out, which has the colour of Adrianople red, and which fixes on white cotton. Mr. Oetingen had obſerved * in 1764, that oil had the property of diſſolving the colouring matter of the Adrianople red, ſo that, if it be moiſtened with oil, its colour is communicated to white cotton when rubbed with it for ſome time. He had thence concluded, that oil muſt enter into the preparation of Adrianople red; and the Abbé Mazéas has long ago proved that the uſe of oil in that dye was indiſpenſable †.

The kind of madder employed has great influence on the colour produced. It appears abſolutely neceſſary to employ that which is called lizary, in order to obtain a colour equal to the Adrianople red.

With reſpect to the choice of madder, we muſt recollect that Meſſrs. D'Ambourney and Beckmann recommend the uſe of freſh madder; but it is generally ſuppoſed that it gives a more beautiful colour, when kept for a year or two before it is uſed; and Mr. Guhliche ſays, that the old madder gives a colour nearly as beautiful as lizary. There are caſes perhaps in which the uſe of freſh madder would be advantageous; the choice of the young roots would certainly be proper.

Berthollet having expoſed for a long time to the inclemencies of the weather, the cotton which he had dyed with the addition of calx of tin to the madder bath, that, for which the ſolution of alumine in nitrous acid had been employed as mordant, and a pattern of Adrianople cotton; the colour of the firſt remained

* Diſſert. de Viribus Radic. Rubiæ Tinct. Antirachiticis a Virtute Oſſa Animal. vivorum tingendi non pendentibus.

† Recherches ſur la Cauſe Phyſ. de l'Adhérence de la Couleur Rouge, &c. Mem. des Sav. Etrang. tome iv.

longeſt

longeſt without any ſenſible change; at laſt however it acquired a yellow hue; the ſecond acquired a yellowiſh tinge ſooner; the colour of the third was impaired ſooneſt, but it did not change its hue (ton).

From this experiment it follows, that we may conſider in cotton dyed with madder, its power of reſiſting the action of the air for a long time, or that of reſiſting alkalis or ſoap. This laſt can only be obtained by means of oils and greaſe; but the firſt depends principally on the mordants employed, and the number of dryings. It is therefore proper, independent of the beauty of the colour, to employ proceſſes ſimilar to that of Adrianople, for ſuch ſtuffs as are to be ſubjected to leying or frequent waſhing with ſoap.

Mr. Wilſon makes an obſervation which is worthy of attention. He ſays, that ſtuffs made of cotton which has not been ſpun by Mr. Arkwright's machines, cannot be dyed by the Adrianople proceſs, becauſe the filaments of the cotton are made to briſtle up (ſe hériſſent) in the numerous operations of this proceſs; but that theſe filaments preſerve their parallelifm much better when the cotton has been ſpun and carded by theſe machines, and that the ſtuffs can then undergo the ſame operations without injury to their texture *.

But as colours which ſuſtain the action of the air as well as the Adrianople red, may be obtained by ſhorter proceſſes, and as cotton ſtuffs are not intended to be ſubmitted to leying and frequent waſhing, proceſſes analogous to ſome of thoſe deſcribed above, may frequently be employed with advantage.

One circumſtance which ought not to be omitted, is, that aerated marine acid repreſented the action of the air on the madder reds expoſed to its influence, indicating the patterns which would reſiſt its action moſt powerfully; while the nitrous acid on the contrary indicates the cotton dyed in the Adrianople manner, by giving it a yellow colour, as Mr. Vogler has obſerved: this effect ſeems to depend on the combination of the animal oil with the cotton, to which, as to all other animal ſubſtances, the nitrous acid gives a yellow colour by deſtroying the proper colour of the madder: it is this combination of animal oil with the cotton, which forms the diſtinguiſhing characteriſtic of this ſpecies of dye: a different kind of oil might produce a bright colour, but probably it would not be ſo durable.

Berthollet alſo tried the calx of tin in dyeing wool. The decoction of madder acquires a more clear and lively red by the addition of this calx; its colouring particles became fixed much more quickly and more abundantly, upon cloth which had been prepared by a decoction of alum and tartar in the ordinary manner. The cloth came out of the dye bath of a much more ſaturated and beautiful red, than a ſimilar pattern dyed with an equal weight of madder, without calx of tin; the advantage however does not appear to me ſo great, as to render the proceſs worthy of being commonly employed.

Calx of zinc uſed inſtead of tin, produced a fine orange colour in the cloth; calx of lead, a dull brick colour; that of iron had no ſenſible effect.

MAGISTERY. Chemiſts formerly applied this term to almoſt all precipitates; at preſent it is applied only to a few, which have retained the name, from habitual uſage.

MAGISTERY OF BISMUTH. The calx of biſmuth precipitated from its ſolution in nitrous acid by the addition of a large quantity of water. To make this preparation, which is a fine white powder, very pure biſmuth muſt be diſſolved

* An Eſſay on Light and Colours, &c.

in pure nitrous acid. To this ſolution a large quantity of water, the purer the better, muſt be added. The whole immediately becomes of a milky white, by the diffuſion of the calx, which ſeparates, and at length ſubſides; the cler fluid muſt then be decanted off, and the calx thrown upon a filtre to be edulcorated by repeated affuſions of water. Some artiſts precipitate the biſmuth by a fixed alkali, but in this way the magiſtery is not ſo white; probably from the impurity of moſt common alkalis, or perhaps from the ſtate of the calx itſelf, which may carry down fixed air.

The chief uſe of the magiſtery of biſmuth is to enter into the compoſition of white paint uſed by ladies. It is preferred to all other whites from its ſuperior beauty, its luſtre, and an almoſt inſenſible tint of carnation, which renders it more ſimilar to the fineſt and whiteſt ſkin.

MAGISTERY OF CORAL. This name has been given to the calcareous powder obtained by diſſolving coral, crabs-claws, chalk, or other ſubſtances of the like nature, in nitrous acid, precipitating with a fixed alkali, and waſhing the precipitate in a ſufficient quantity of water.

MAGISTERY OF SULPHUR. The powder of ſulphur which is thrown down from a ſolution of liver of ſulphur, by the addition of an acid.

MAGNESIA. See EARTH MAGNESIAN.

MAGNESIA BLACK. Modern chemiſts are agreed in uſing the denomination manganeſe for this ſubſtance, which ſee.

MAGNET. The loadſtone. When a bar of iron or ſteel is rendered magnetical, it is called an artificial magnet. The uſage of modern writers has almoſt entirely confined the word magnet to this laſt inſtrument. It is uſeful to the chemiſt in making an inaccurate ſeparation of ſubſtances containing iron from pulverized mineral matters, after a ſlight calcination.

MAGNETISM. The property by which iron exhibits a peculiar and ſtrong attractive and repulſive power upon other iron, according to circumſtances. For the general facts, recourſe muſt be had to writers on natural philoſophy, as they do not particularly appertain to the chemical department. All iron whoſe dimenſions in length greatly exceed its other dimenſions is very evidently magnetical, while held in a vertical poſition in theſe latitudes; but the property diminiſhes and diſappears the more that poſition is altered. Properly ſpeaking, the poſition moſt favourable for this magnetiſm is not the vertical one, but that which a magnetical bar truly poiſed, and at liberty to aſſume any poſition, is diſpoſed of itſelf to take when this power is communicated to it. It is obſerved, that the magnetiſm of mere poſition becomes permanent in bars of iron which have long remained vertical; and that heating and cooling, indentation by blows, filing, the electrical ſhock, or any other cauſe which may agitate the whole maſs, while in this ſituation, will render the magnetiſm permanent; and accordingly it is found that the poker, tongs, and other ſimilar utenſils, ſoon acquire a fixed magnetiſm by uſe. The magnetiſm of three equal bars of ſteel may be rendered much more conſiderable by a manipulation called the touch, which appears to depend on this principle, that a ſingle weak bar, will become ſtronger in its power by being rubbed at the ſame time by two other weak bars; that one of the two touching bars being then ſubjected to the touch from both the others, will become ſtronger than the bar firſt touched, by reaſon of the ſuperior power of the touching bars, one of which had its energy increaſed by the preceding operation; that if the untouched bar be then laid down and ſubjected to the touch from the two others, it will, upon the ſame principle, become the ſtrongeſt of the three: and,

by

by repetitions of this proceſs, all the bars may be brought to a greater degree of magnetical power than they are capable of retaining. What happens in theſe proceſſes, as well as in every thing elſe relating to magnetiſm, is ſo entirely unknown, that we do not poſſeſs even a probable hypotheſis on the ſubject.

MALACHITE. A ſolid green copper ore, which is ſometimes cut and poliſhed as a gem. It has the appearance of green jaſper; but is not ſo hard, ſince it does not ſtrike fire with ſteel. It is either of a radiated or uniform texture, generally of an oval form, and of the ſize of an egg; but ſometimes it is formed of capillary filaments, like ſatin, and ſhews a kind of concentric ſtripes, or ſhreds, of paler colours, when cut and poliſhed; its external appearance is like a thick ſhell, with various protuberances of a mamillary form. The ſilky-green copper ore of this kind from China, in the form of ſolid bundles, is the pureſt. It is found alſo in great quantity on the Voſges, mountains ſo called in Lorraine, and in the mines of the Hartz in Saxony.

According to Kirwan, the pureſt malachite contains 75 parts of copper, and 25 of aerial acid. Its ſpecific gravity, according to Muſſchenbroeck, is from 3,500 to 3,994. It is ſometimes mixed with calcareous earth and gypſum, and is found in Norway and Siberia. KIRWAN.

MANGANESE. The regulus of manganeſe is a ſemi-metal of a dull whitiſh colour when broken, but ſoon grows dark by calcination from the action of the air. It is hard, brittle, though not pulverizable, and rough in its fracture; ſo difficultly fuſible, that no heat yet exhibited has cauſed it to run into maſſes of any conſiderable magnitude, and it appears to be more diſpoſed to calcination than any other metallic ſubſtance, unleſs we may except wolfram. Its calces are white when imperfect, but black, or dark green, when perfect: the white are ſoluble in acids. When broken in pieces, it falls into a powder by ſpontaneous calcination; and this powder is magnetic, though the maſſes were not poſſeſſed of that property. It ſeems as if the regulus of manganeſe were capable of depriving a ſmall proportion of iron of its magnetiſm, but that the effect ceaſes as ſoon as that regulus is converted into calx: a ſtrong heat expels vital air from the calx of manganeſe.

Concentrated vitriolic acid attacks the regulus of manganeſe, but much more readily when diluted with two or three times its weight of water; at the ſame time that inflammable air is diſengaged. A black ſpongy ſubſtance remains undiſſolved, which has not been examined. The ſolution is colourleſs, and affords cryſtals by evaporation. Mild alkalis precipitate a white calx ſoluble in acids; but pure alkalis afford a brown calx, which ſoon grows black in the air, and is ſcarcely ſoluble. The black calx of manganeſe, when old, or well made, is altogether inſoluble in acids, unleſs ſome combuſtible ſubſtance be added. It appears, therefore, that the metal in this ſtate is too far calcined, and requires to be reduced again in a certain degree towards the metallic ſtate, to be diſſolved. If vitriolic acid be added, and drawn off by diſtillation ſeveral times from the black calx, by an heat nearly approaching to ignition, in a glaſs veſſel, it is found that vital air is diſengaged towards the end of each proceſs, and part of the calx is diſſolved. The ſolution of the calx in acids, by the addition of combuſtible matter, is eaſily accounted for, on either of the theories of chemiſtry, by affirming that the reduction is effected by the addition of phlogiſton, or the ſubtraction of vital air from the calx, by means of the combuſtible ſubſtance. The phlogiſtic theory appears, however, to be deficient, in explaining the ſolution by mere

vitriolic

vitriolic acid, at an elevated temperature*, on account of the abſence of phlogiſton; but the new theory ſimply aſſerts the facts, that the calx loſes vital air in conſequence of the elevated temperature, and is rendered ſoluble in the acid.

Nitrous acid diſſolves the regulus of manganeſe with efferveſcence, and the eſcape of nitrous air. A ſpongy, black, and friable matter remains, whoſe properties reſemble molybdena. The ſolution does not afford cryſtals. The perfect calx is not ſoluble in pale nitrous acid, unleſs ſome combuſtible matter be added.

The regulus is diſſolved in the uſual manner, by marine acid. The black calx is likewiſe ſoluble; but adheres ſo weakly to the acid, as to be ſeparated even by the mereaddition of water: but, if this ſolution be expoſed to a digeſting heat for ſome hours, an inteſtine motion, like an efferveſcence, takes place; the ſmell of dephlogiſticated or aerated acid is perceived, and the combination becomes more perfect, ſo as not to afford a precipitate, unleſs an alkali be added. Marine acid diſſolves the black calx alſo, by the addition of a combuſtible ſubſtance: mercury, and even gold, will effect this combination. The ſolution of manganeſe in marine acid ſcarcely affords cryſtals; but a deliqueſcent ſaline maſs by evaporation, which is ſoluble in ardent ſpirit.

In the permanent ſolution of black calx of manganeſe by marine acid, it is ſeen that the acid itſelf muſt communicate the property to the calx, on which its ſolubility depends; that is to ſay, it muſt either afford phlogiſton, or abſorb vital air: and accordingly the red vapours which eſcape are diſtinguiſhed by the name of dephlogiſticated, or aerated, marine acid, according to the theory which may be adopted by the ſpeaker.

Other acids likewiſe diſſolve this metallic ſubſtance: the fluor acid, and alſo the phoſphoric acid, form compounds of different ſolubility, which envelop and defend it from their farther action in a ſhort time.

In the dry way, the calx of manganeſe combines with ſuch earths and ſaline ſubſtances as are capable of undergoing fuſion in a ſtrong heat. Theſe experiments are moſt advantageouſly performed by the blow-pipe, on ſmall quantities of matter; becauſe in this way the whole of the phænomena are clearly ſeen. The moſt remarkable property of the ſolutions is, that a due proportion of combuſtible matter renders them colourleſs; for which reaſon, the calx of manganeſe is uſed by the glaſs manufacturers to deſtroy the colours of glaſs. If a globule of microcoſmic ſalt be fuſed by the blow-pipe upon charcoal, and a ſmall portion of the black calx of manganeſe be added, the colour will be of a blueiſh red; or of a deep red, if the quantity of calx be greater. If the fuſion be continued by the interior blue flame, the colour at length diſappears; but may be eaſily revived again, by ſoftening the globule with the exterior flame. A ſmall particle of nitre inſtantly reſtores the red colour; but inflammable matter, or vitriolic ſalts, contribute to diſcharge it. If the globule, after being deprived of all colour, be fuſed in the ſilver ſpoon, it recovers its redneſs; and the colour is not diſcharged by any management of the fuſion, unleſs ſome inflammable matter be added.

Theſe remarkable changes of colour, which may be repeatedly produced, depend evidently on the preſence or abſence of combuſtible matter; or, which amounts to the ſame thing, on the degree of calcination of the manganeſe which is held in ſolution. When the highly calcined or black manganeſe is firſt added, it

* Bergman, ii. 215, (on the hypotheſis, that heat is matter; that the matter conſiſts of pure air united to the phlogiſton; and that manganeſe decompoſes the heat) derives the phlogiſton required for the ſolution, as well as the vital air which flies off, from this decompoſition. Theſe poſitions do not appear to be ſufficiently eſtabliſhed.

produces

produces a coloured globule; if inflammable matter be added, the calx is partly reduced, and forms a colourleſs combination: nitre reſtores the colour by its well-known property of calcining metals. When the fuſion is performed by the interior flame, the globule may be conſidered as if heated in a cloſe veſſel, in contact with charcoal; becauſe the ſurrounding flame prevents the acceſs of air: a revival of the calx therefore enſues, and the colour vaniſhes. But when the external flame is uſed, its apex or point only touches the globule; and the ſurrounding air promotes or maintains the calcination more effectually than the charcoal can produce the contrary effect; the conſequence therefore is, that the colour again appears. Vitriolic ſalts ſeem to forward the action of the charcoal, which converts them into ſulphur; and the colour remains fixed in the ſpoon, becauſe there is no combuſtible ſubſtance preſent, which is ſufficiently ſo to promote the revival of the calx. It is evident, that both the theories of chemiſtry are applicable to theſe facts, whether the charcoal revives the calx by phlogiſticating it, or by depriving it of its vital air; or whether the calcination by the apex of the flame be effected by the diſſipation of phlogiſton, or by the abſorption of vital air from the atmoſphere.

Nearly ſimilar changes are produced when the calx is fuſed with borax, or an alkali.

Regulus of manganeſe does not appear to combine with ſulphur; but eight parts of the calx combine with three of ſulphur, and produce a yellowiſh green maſs, which is acted upon by acids; the metal being diſſolved with efferveſcence, and the diſengagement of hepatic air. The remaining ſulphur may be collected on a filter.

This ſemi-metal melts readily with moſt of the other metals, but rejects mercury. Gold and iron are rendered more fuſible by a due addition of manganeſe; and the latter metal is rendered more ductile. Copper becomes leſs fuſible, and is rendered whiter, but of a colour ſubject to tarniſh*.

Regulus of manganeſe has been found native among the powdery or calciform ore of this metallic ſubſtance. Its properties, in this ſtate, perfectly reſembles the regulus produced by art. Manganeſe appears to exiſt in the calcined ſtate in all its ores; though contaminated with admixtures of earths, or other metallic matters. They are white, red, brown, or black; either pulverulent, indurated, or cryſtallized. Vegetable aſhes likewiſe afford indications of manganeſe.

To analyſe the ores of manganeſe in the humid way, they muſt be reduced to a ſubtle powder, and immerſed in a mineral acid, with a piece of ſugar to aſſiſt the ſolution. If nitrous acid be repeatedly abſtracted to ignition from the ore, the iron it contains will be rendered nearly inſoluble from calcination, and the manganeſe may be taken up by ſtrong concentrated vinegar, or diluted nitrous acid. This, when precipitated by mild mineral alkali, affords 180 grains of precipitate for every 100 grains of regulus: or if the metals be precipitated from ſuperabundant nitrous acid, by Pruſſian alkali, the manganeſe will be totally diſſolved by pure water, while the iron remains behind.

The ore of manganeſe, which is known in Derbyſhire by the name of black wadd, is remarkable for its ſpontaneous inflammation with oil. It is of a dark brown colour, of a friable earthy appearance, partly in powder, and partly in lumps. If half a pound of this be dried before a fire, and afterwards ſuffered to cool for about an hour; and it be then looſely mixed or kneaded with two ounces of linſeed oil; the whole, in ſomething more than half an hour, becomes gra-

* Annales de Chimie, i. 303.

dually hot, and at length burſts into flame. This effect wants explanation. It ſeems, in ſome meaſure, to reſemble the inflammation of oils by the nitrous acid.

The preſence of manganeſe may be aſcertained in the dry way by the blow-pipe, from the ſingular changes of colour already deſcribed, when fuſed with microcoſmic ſalt, or borax. The reduction of the ore is effected by mixing it with pitch, making it into a ball, and putting it into a crucible lined with powdered charcoal, one-tenth of an inch thick at the ſides, and one-quarter of an inch thick at the bottom; then filling the empty ſpaces with powdered charcoal, and luting on a cover. This muſt be expoſed to the ſtrongeſt heat of a forge, or furnace, for an hour, or more. As the calx of manganeſe is ſtrongly diſpoſed to vitrification, fluxes rather impede than forward the reduction. The reduced globules of manganeſe are uſually enveloped with a vitrified cruſt, which either partly or completely defends them from the action of the air; but, when they are broken, they loſe their metallic brilliancy and conſiſtence in a very ſhort ſpace of time.

Manganeſe has hitherto been uſed chiefly by glaſs-makers and potters; but the important diſcoveries of the uſes of dephlogiſticated or aërated marine acid will, no doubt, extend its utility to ſeveral other manufactories *. See ACID, MARINE AERATED, alſo BLEACHING.

MANNA. Several vegetables afford manna; it is extracted from the pine, the fir, the maple, the oak, the juniper, the fig, the willow, the olive, &c. but the aſh, larch, and the alhagi, afford it in the largeſt quantitities. Lobel, Rondelet, and others, have obſerved at Montpellier, upon the olive trees, a kind of manna, to which they have given the name of oeliomeli. Tournefort collected it from the ſame trees at Aix and at Toulon.

The aſh which affords manna grows naturally in all temperate climates; but Calabria and Sicily appear to be the moſt natural countries to this tree; or at leaſt it is only in theſe countries that it abundantly furniſhes the juice called manna in commerce.

The manna flows naturally from this tree, and attaches itſelf to its ſides in the form of white tranſparent drops; but the extraction of this juice is facilitated by inciſions made in the tree during ſummer: the manna flows through theſe apertures upon the trunk of the tree, from which it is detached with wooden inſtruments. Care is likewiſe taken to inſert ſtraws, or ſmall ſticks of wood, into theſe inciſions; and the ſtalactites which hang from theſe ſmall bodies are ſeparated, and known in commerce by the name of Manna in Tears: the ſmalleſt pieces form the manna in ſorts or flakes, and the common or fat manna is of the worſt quality, becauſe the moſt contaminated with earth and other foreign ſubſtances. The aſh ſometimes afford manna in our climates, ſpecimens of which Chaptal ſaw collected in the vicinity of Aniane.

The larch, which grows abundantly in Dauphiny and the environs of Briançon, likewiſe affords manna. It is formed during the ſummer on the fibres of the leaves, in white friable grains, which the peaſants collect and put into pots, which they keep in a cool place. This manna is of a yellow colour, and has a very nauſeous ſmell.

The alhagi is a kind of broom, which grows in Perſia. A juice tranſudes from its leaves in the form of drops of various ſizes, which the heat of the ſun indurates. An intereſting account of this tree may be ſeen in Tournefort's Travels. This manna is known in the Levant, in the town of Tauris, by the name of Tereniabin.

* On manganeſe, conſult Scheele, 67—142; Bergman, ii. 201—225; the Memoirs of Pelletier, Berthollet, &c.; and the Abſtracts by Elementary Writers on Mineralogy.

The manna moſt frequently uſed is that of Calabria. Its ſmell is ſtrong, and its taſte ſweetiſh and nauſeous: if expoſed on hot coals, it ſwells up, takes fire, and leaves a light bulky coal.

Water totally diſſolves it, whether hot or cold. If it be boiled with lime, clarified with white of egg, and concentrated by evaporation, it affords cryſtals of ſugar. See SUGAR.

Manna affords, by diſtillation, water, acid, oil, and volatile alkali: its coal affords fixed alkali.

This ſubſtance forms the baſis of many purgative medicines.

MARBLE. All calcareous ſtones which are hard, of a cloſe texture, and beautiful appearance, from the clearneſs and uniformity of their colour, or from its variety and admixture, are diſtinguiſhed by the name of marble. For an enumeration of the ſeveral kinds, Cronſtedt's Mineralogy may be conſulted. The different names apply chiefly to circumſtances of outward appearance, much more important to the ſtatuary and the builder than to the chemiſt.

MARCASITE. This name has long been given indifferently to all ſorts of minerals, to ores, pyrites, and to ſemi-metals. At preſent it ſeems to be confined to pyrites; and Wallerius propoſes to apply it only to ſuch pyrites as are regularly formed. This appears to be better than to leave it to a vague and indeterminate ſignification, from the ambiguity and obſcurity which might thereby be introduced. The word is little uſed. See PYRITES.

MARGODES. A blueiſh grey ſtone, entirely reſembling clay in its outward appearance, but ſo hard as to cut ſpars, or even zeolytes, though not to ſuch a degree as to give fire with ſteel; dull in its fracture, its texture thick lamina, and of a conchoidal form; its ſpecific gravity 2.877; it effervеſces with acids. Kirwan found it to contain 50 per cent. of calcareous earth, about 32 of clay, 15 of ſilex, and two of iron.

MARLE. There are two kinds of marle; for which ſee EARTH, FULLER'S, the one conſiſting of clay divided by a very fine fuller's earth, and the common marle, conſiſting of clay divided by calcareous earth. Common marle participates in its properties of thoſe of its reſpective component parts. When crude, it effervеſces with acids; but does not after it has been burned. It hardens in the fire like clay, and the more ſo, the larger the quantity of clay which enters into its compoſition; but it falls into powder by expoſure to the air like lime, and this the more readily, the greater the quantity of lime. A ſtrong heat converts it into glaſs. See EARTH CALCAREOUS.

It is found either looſe and friable, or more or leſs indurated. The ſemi-indurated marle is nearly as hard as a ſtone, when firſt dug up, but falls to pieces in the open air.

Marle is of excellent ſervice for the improvement of lands, which it appears to do by altering the proportion of their component parts. See ARABLE LAND, and EARTH, VEGETABLE.

The Engliſh farmers diſtinguiſh ſix ſorts of marle: 1. The coro-ſhut marle, which is brown mixed with fragments of chalk and blue veins. 2. Stone ſlate, or flag-marle: it reſembles blue ſlate, and crumbles eaſily when expoſed to the air. 3. Pont marle, or delving marle; it is brown, and rough to the touch. 4. Clay-marle: which contains much clay. 5. Steel-marle: its colour is black, its conſiſtence like that of bits of paper.

MARMOR METALLICUM. See SPAR PONDEROUS.

MARS. Chemiſts have diſtinguiſhed iron by the name of the planet Mars, whence the term martial is ſtill much uſed to denote compounds containing that metal.

MASSICOT. Yellow calx of lead. See MINIUM.

MASTIC. A reſinous ſubſtance in the form of white tears, of a farinaceous appearance, having little ſmell, and a bitter aſtringent taſte. It flows naturally from the tree, but its produce is accelerated by inciſions. The leſſer turpentine tree and the lentiſcus afford the maſtic in commerce.

No volatile oil is obtained from this ſubſtance when diſtilled with water. Pure ardent ſpirit almoſt totally diſſolves it; water ſcarcely acts upon it; though by maſtication it becomes ſoft and tough, like wax. It is uſed in fumigations, in the compoſition of varniſhes, and is ſuppoſed to ſtrengthen the gums.

MATRASS. See APPARATUS.

MATRIX. The earthy or ſtony matters which accompany ores, or envelop them in the earth, are called the matrixes of thoſe ores. They are various, and the information they afford to miners is not eaſily reducible to rule. It has been remarked, that it is generally found among cryſtalline or ſiliceous ſtones, and lead among thoſe of the calcareous order.

MATT. Certain metallic ores, particularly that of copper, are diſtinguiſhed by this name when partly deprived of ſulphur, and fuſed into a maſs with the remaining portion of that ſubſtance.

MATTER. When philoſophers ſpeak of the ſubſtance which compoſes the things around us, in the moſt general way, they uſe the term *matter*. This term is more abſtract than the word *body*, which includes the conſideration of limit; but it is leſs abſtract than the words *being* or *thing*, which are applicable to ſubſtances which do not poſſeſs all the common properties of bodies, if indeed it be true, that any ſuch ſubſtances exiſt.

MEASURES. The Engliſh meaſures of capacity are according to the following table.

One gallon, wine meaſure, is equal to four quarts.
One quart, —— two pints.
One pint, —— 28,875 cubic inches.

The gallon, quart, and pint, ale meaſure, are to the meaſures of the ſame denominations, wine meaſure, reſpectively, as 282 to 231.

The French meaſures of quantity uſed by chemiſts:

The quarte is equal to two pintes.
The pinte — two chopines.
The chopine — two demi-ſetiers.
The demi-ſetier — two porçons.
The porçon — four Paris ounces of water at the freezing point. The proportion of the Paris ounce to the Engliſh troy ounce is, as 65 to 64.

As to the meaſures of length, it is ſufficient to obſerve here, that the Paris foot is equal to 12.785 Engliſh inches, or to the Engliſh foot, as 114 to 107. For meaſures of weight, ſee BALANCE.

MELASSES. The juice of the ſugar cane. See SUGAR. Treacle, or the reſidue after the ſeparation of the cryſtals of ſugar at the works, is exported to America and Europe, from the ſugar iſlands, where it is fermented and diſtilled. The ſpirit thus obtained is called Melaſſes' ſpirit.

MENSTRUUM. A word ſynonymous with ſolvent.

MERCURY is diſtinguiſhed from all other metals by its extreme fuſibility, which is ſuch, that it does not take the ſolid ſtate until cooled to the thirty-ninth degree below o on Fahrenheit's thermometer; and of courſe it is always fluid in the temperate climates of the earth. Its colour is white, and rather bluer than ſilver. In the ſolid ſtate it is malleable *; its ſpecific gravity is greater than that of any of the other metals, platina, gold, and wolfram excepted. It is volatile, and riſes in ſmall portions at the common temperature of the atmoſphere, as is evinced by ſeveral experiments, more eſpecially in a vacuum, ſuch as obtains in the upper part of a barometer tube. At the temperature of about ſix hundred degrees it boils rapidly, and riſes copiouſly in fumes. Few of the other metals melt at ſo low a temperature as the boiling point of mercury. When expoſed to ſuch a heat as may cauſe it to riſe quickly in the vaporous form, it gradually becomes converted into a red calx, provided vital air be preſent. This is known by the name of precipitating *per ſe*. A greater heat however revives this metallic calx, at the ſame time that the vital air is again extricated.

Mercury is not perceptibly altered by mere expoſure to the air; though by long agitation, with acceſs of air, it becomes converted into a black powder or calx, which gives out vital air by heat, the metal being at the ſame time revived. This metal is diſpoſed to attract moiſture; and cannot, for that reaſon, be uſed in the conſtruction of barometers and thermometers, until it has been firſt boiled in an open veſſel for the ſpace of about half an hour.

When mercury is agitated in a dry glaſs bottle, the friction between the metal and the glaſs produces electricity. If the bottle be imperfectly exhauſted, this electricity paſſes into the vacuum, and produces a light, which was formerly thought to be a proof of the perfection of the vacuum in the upper part of barometer tubes; but which, in fact, does not appear in ſuch barometers as have been cleared of air by careful boiling in the tube.

The vitriolic acid does not act on this metal, unleſs it be well concentrated and boiling. For this purpoſe mercury is poured into a glaſs retort, with near twice its weight of vitriolic acid. As ſoon as the mixture is heated, a ſtrong effervescence takes place, vitriolic acid air eſcapes, the ſurface of the mercury becomes white, and a white powder is produced: when the vitriolic air ceaſes to come over, the mercury is found to be converted into a white, opake, cauſtic, ſaline maſs, at the bottom of the retort, which weighs one third more than the mercury, and is decompoſed by heat. Its fixity is conſiderably greater than that of mercury itſelf. If the heat be raiſed, it gives out a conſiderable quantity of vital air, the mercury being at the ſame time revived.

The white maſs produced by the action of vitriolic acid upon mercury, conſiſts partly of a ſaline maſs, or vitriol of mercury, and partly of a calx, or mercury united to vital air (ſimply, according to the new theory; or deprived of phlogiſton, according to the old theory, which phlogiſton is ſuppoſed to enter into the combination of the vitriolic acid air). Water ſeparates the ſalt from the calx, which laſt is then of a yellow colour. Much waſhing is required to produce this colour, if cold water be uſed; but if a large quantity of hot water be poured on, the calx immediately aſſumes a bright lemon colour. In this ſtate it is called turbith mineral.

* The reader will find an ample account of the freezing of quickſilver in Dr. Blagden's Hiſtory, vol. lxxxiii. of the Philoſophical Tranſactions.

The

The vitriol of mercury affords a ſalt by evaporation, in ſmall needle-formed deliqueſcent cryſtals. The addition of a large quantity of water, more eſpecially if heated, decompoſes vitriol of mercury, which depoſits turbith mineral, unleſs there be an exceſs of acid in the fluid.

The fixed alkalis, magneſia, and lime, precipitate mercury from its ſolution: theſe precipitates are reducible in cloſed veſſels by mere heat without addition.

The nitrous acid rapidly attacks and diſſolves mercury, at the ſame time that a large quantity of nitrous air is diſengaged; and the colour of the acid becomes green during its eſcape. Strong nitrous acid takes up its own weight of mercury in the cold; and this ſolution will bear to be diluted with water. But if the ſolution be made with the aſſiſtance of heat, a much larger quantity is diſſolved; and a precipitate of calx will be afforded by the addition of diſtilled water, which is of a yellow colour if the water be hot, or white if it be cold; and greatly reſembles the turbith mineral produced with vitriolic acid: it has accordingly been called nitrous turbith. If acid be added to the ſolution made with heat, it loſes its property of being decompoſed by water. This decompoſition is not complete, but only deprives the acid of the redundant calx.

All the combinations of mercury and nitrous acid are very cauſtic, and form a deep purple or black ſpot upon the ſkin. They afford cryſtals, which differ according to the ſtate of the ſolution. When nitrous acid has taken up as much mercury as it can diſſolve by heat, it uſually aſſumes the form of a white ſaline maſs. When the combination of nitrous acid and mercury is expoſed to a gradual and long continued low heat, it gives out a portion of nitrous acid, and becomes converted into a red ſubſtance, ſimilar in all reſpects to the red calx of mercury formed by ſimple heating it in contact with vital air. This is known by the name of red precipitate.

When red precipitate is ſtrongly heated, a large quantity of vital air is diſengaged, together with ſome phlogiſticated air, and the mercury is ſublimed in the metallic form.

Mercurial nitre is more ſoluble in hot than cold water, and affords cryſtals by cooling. It is decompoſed by the affuſion of a large quantity of water, unleſs the acid be in exceſs.

When mercury is diſſolved in nitrous acid by means of heat, nitrous air is emitted at firſt; and afterwards it ceaſes, though the ſolution ſtill proceeds. The mercury which is taken up during the firſt part of the proceſs is calcined, and the other portion is diſſolved in the metallic ſtate. If the ſolution be ſtopped in the firſt part of the proceſs, fixed and volatile pure alkalis precipitate the yellow calx; but if the ſolution be continued after the eſcape of the elaſtic fluid has ceaſed, the precipitate obtained by the ſame means is black, on account of the admixture of metallic mercury, which may be ſeparated from the yellow calx by diſtillation.

Ponderous earth, magneſia, and lime, precipitate the nitrous ſolutions of mercury; and theſe precipitates, as well as all the other calces of this metal, are reducible by heat alone without addition.

The precipitates of mercury from acids, by means of alkalis, poſſeſs the property of exploding when expoſed to a gradual heat in an iron ſpoon, after having been previouſly triturated with one-ſixth of their weight of flowers of ſulphur. The reſidue conſiſts of a violet-coloured powder, which is converted by ſublimation into cinnabar. It ſeems therefore as if the ſulphur combined ſuddenly with the mercury, and expelled vital air in the elaſtic ſtate.

The

The vitriolic acid, or the ſalts containing it, decompoſe the nitrous ſolutions of mercury by virtue of the ſtronger attraction of the vitriolic acid to the metal. The precipitate which falls down does not eſſentially differ from the ſubſtance produced by the direct ſolution of mercury in the vitriolic acid. The marine acid likewiſe ſeizes the mercury diſſolved in the nitrous acid, and forms a compound which falls to the bottom. This conſiſts of a very cauſtic ſalt, which is called corroſive ſublimate, and is produced when the nitrous ſolution contains only calx of mercury; but when that ſolution is ſaturated with metallic mercury, the compound which falls down by the addition of marine acid is called white precipitate, and does not differ from the preparation which, when made in the dry way, is called calomel, or mercurius dulcis.

The acetous and moſt other acids combine with the calx of mercury, and precipitate it from its ſolution in the nitrous acid.

The marine acid does not act perceptibly upon mercury in the metallic ſtate; but the dephlogiſticated or aërated marine acid readily diſſolves it, and forms the ſame combination as ariſes from the direct union of marine acid with calx of mercury; that is to ſay, corroſive ſublimate.

The great ſpecific gravity of mercury rendered it an object of peculiar attention to the alchemiſts and earlier chemiſts; many of whom hoped to fix it in the form of a ſolid ſubſtance, or to extract gold from it. From theſe motives, a great variety of proceſſes have been made with it, by methods which are much leſs direct and ſimple than thoſe of modern chemiſtry. Among others, the combination of the calx of mercury with marine acid is produced by ſeveral methods in the dry way by ſublimation. In the large way, corroſive ſublimate is prepared by triturating equal parts of mercury, common ſalt, and vitriol together, and expoſing the whole to a moderate heat. The corroſive ſublimate riſes, and adheres to the upper part of the glaſs veſſel. In this operation the vitriolic acid from the vitriol is ſuppoſed to calcine the mercury, or to dephlogiſticate the marine acid of the common ſalt; in either of which caſes the compound of marine acid with calx of mercury will be formed. From this theory, it will eaſily be underſtood that corroſive ſublimate may be prepared by various methods. If the white maſs or calx of mercury, produced by expoſing that metal to the action of vitriolic acid, be heated in a matraſs with an equal quantity of common ſalt, this ſublimate will be had by double affinity; the vitriolic acid partly ſaturating the alkali, and the marine acid uniting with the calx of mercury, and riſing by ſublimation. In the ſame manner, the nitrous mercurial ſalt, or the mercurial precipitates, may be uſed inſtead of the calx of mercury by vitriolic acid.

As the cauſticity of metallic ſalts depends chiefly on the diſpoſition of the calcined metal to reſume the metallic ſtate, at the ſame time that it burns or calcines the ſubſtance to which it may be applied; it is accordingly found that corroſive ſublimate poſſeſſes this property in the moſt eminent degree; it is therefore one of the moſt active mineral poiſons. This ſalt is ſoluble in water, though ſparingly, and alſo in ardent ſpirit. It is precipitated of an orange colour by fixed alkalis. The abſorbent earths likewiſe throw down its calx. Volatile alkali affords a white precipitate, which ſoon afterwards aſſumes a ſlate colour.

Corroſive ſublimate becomes much more ſoluble in water by the addition of ſal ammoniac, with which it forms a triple compound, called ſal alembroth by the alchemiſts, which cryſtallizes by cooling. The addition of a fixed alkali throws down a white calx of mercury, called white precipitate in the diſpenſatories.

The

The preparation of calomel is uſually made by triturating corroſive ſublimate in a glaſs mortar with fluid mercury, added by a little at a time, until no more can be made to diſappear. A ſmall quantity of water added to the corroſive ſublimate during this part of the proceſs, prevents that ſalt from riſing in the form of noxious duſt. In this ſtate the combination is the ſame as that obtained from the ſaturated nitrous ſolution of mercury by the addition of marine acid. The mixture of corroſive ſublimate and mercury is more perfectly combined by expoſing it to ſublimation. It adheres to the internal part of the ſubliming veſſel, in the form of a white maſs of a ſtriated texture. If there be any ſuſpicion of its containing corroſive ſublimate, which is not probable on account of the more volatile nature of the latter, they may be ſeparated by means of warm water, the calomel being inſoluble.

When one part of antimony, which is the native combination or ore of antimony with ſulphur, is triturated or accurately mixed with two parts of corroſive ſublimate, and expoſed to diſtillation, the dephlogiſticated or aërated marine acid combines with the regulus of antimony, and riſes in the form of the compound called butter of antimony; while the ſulphur combines with the mercury, and forms cinnabar. If the regulus of antimony be uſed inſtead of the mineral, the reſidue which riſes laſt conſiſts of running mercury, inſtead of cinnabar.

Mercury combines very readily with ſulphur. By trituration in a mortar the mercury diſappears, and forms a black compound with the ſulphur, which is called ethiops mineral, or mercurial ethiops. The combination is more ſpeedily made by mixing fluid mercury with melted ſulphur. In this way three parts of flowers of ſulphur unite with one of mercury. If the ſulphur be ſet on fire, the greateſt part burns, and the remainder is of a violet colour when pulverized. This conſiſts of a more intimate combination of mercury and ſulphur. It riſes in a heat nearly approaching to redneſs; and the ſublimate, which is called cinnabar, contains about one fifth part ſulphur, and the reſt mercury. The pigment called vermilion conſiſts of artificial cinnabar reduced to a powder. See CINNABAR.

Livers of ſulphur are decompoſed in the humid way by mercury, which unites with ſulphur. With the fixed alkaline livers of ſulphur it forms a black powder, or ethiops, by agitation, which in the courſe of a number of years becomes red; but the volatile alkaline hepar, or fuming liquor of Boyle, converts mercury into a fine cinnabar in a very ſhort time. Turbith mineral, and the precipitates of mercury, are likewiſe converted into cinnabar by this alkaline hepar.

Mercury unites by trituration with oils and mucilages, with which it forms black or deep blue compounds. A ſmall part of the mercury in theſe ſeems to be in combination, and the reſt in a ſtate of extreme diviſion.

This metal can ſcarcely be exhibited in the dry way, on account of its volatility. The degree of heat required to convert it into the red calx called precipitate *per ſe*, is rather lower than its boiling point, and a greater reduces it again to the metallic ſtate. The calcination and reduction of mercury, without addition, afford one of the ſtrongeſt arguments in favour of the ſyſtem which rejects phlogiſton.

In the production of the red calx of mercury, it is required that air be preſent, and the metal kept in a ſtate of briſk evaporation. On this account it is found convenient that the veſſel ſhould be ſo deep, and its aperture ſo ſmall, that the fumes may not make their eſcape. It may be inferred, that in this as well as other calcinations there is an abſorption of vital air; more eſpecially as vital air is expelled

expelled from the calx by heat *. When the experiment is made in cloſed veſſels by means of a body whoſe neck is introduced beneath a jar containing common air over mercury, the vital part is abſorbed, and phlogiſticated or foul air remains; and afterwards, by an augmentation of heat, the mercury is revived, at the ſame time that it reſtores the conſtitution of the air by the emiſſion of the vital air. Ten days or a fortnight's conſtant heat is required to convert a few grains of mercury into precipitate *per ſe* in the ſmall way.

Mercury being habitually fluid, very readily combines with moſt of the metals, to which it communicates more or leſs of its fuſibility. When theſe metallic mixtures contain a ſufficient quantity of mercury to render them ſoft at a mean temperature, they are called amalgams.

It very readily combines with gold, ſilver, lead, tin, biſmuth, and zinc; more difficultly with copper, arſenic, and regulus of antimony; and ſcarcely at all with platina or iron: it does not unite with nickel or cobalt; and its action on manganeſe, wolfram, and molybdena, is not known. Looking-glaſſes are covered on the back ſurface with an amalgam of tin. In this operation, mercury is poured on tin foil, upon a flat ſtone, and ſpread with a feather, till its union with the tin has brightened every part of its ſurface. A large quantity of mercury is then poured on, and the glaſs is ſlided along the fluid ſurface; upon which it is afterwards preſſed by weights, to exclude the ſuperfluous mercury.

Mercury is found native in flaty or quartzoſe earths, or viſibly diffuſed through maſſes of clay or ſtone. Native precipitate *per ſe*, or calx of mercury, has alſo been found; and this metal has likewiſe been met with in combination with the vitriolic and marine acids. Its volatility may probably have cauſed it to be overlooked in many minerals that may contain it. The greateſt quantity of mercury is found in combination with ſulphur, in the form of cinnabar. Mercury is a ſcarce metal. Moſt of the mercury in commerce is afforded by the mines of Idria in the Auſtrian dominions, Almaden in Spain, and Guancavelica in Peru. The native mercury requires little more than waſhing to ſeparate it from its matrix. Cinnabar in the native ſtate is frequently mixed with calcareous earth; in which caſe the mercury may be ſeparated by diſtillation, becauſe the calcareous earth combines with and detains the ſulphur. Pure cinnabar may be decompoſed by the addition of about one third of its weight of iron. In all caſes wherein pure mercury is required, it muſt be diſtilled from cinnabar, or its ſulphureous combination. For this purpoſe, the mercury may be converted into ethiops, and diſtilled with twice its weight of quicklime or iron filings. Mercury in commerce is judged to be pure when it is perfectly fluid, and runs in neat globules, without any pellicle on its ſurface, or without ſoiling a funnel of clean white paper, through which it may be poured by a very ſmall aperture at bottom. If it leaves nothing behind after evaporation, its purity may be ſtill more depended on.

To analyſe native cinnabar, its ſtony matrix ſhould firſt be diſſolved in nitrous acid; and the cinnabar, being diſengaged, ſhould be boiled in eight or ten times its weight of aqua regia, compoſed of three parts nitrous, and one marine acid: the mercury may then be precipitated in the metallic form by the addition of zinc.

The uſes of mercury have already been mentioned in the preſent article, and

* Lavoiſier, Traité Elementaire de Chimie, page 35.

elſewhere. The amalgamation of the noble metals, water-gilding, the making of vermilion, the ſilvering of looking-glaſſes, and the preparation of ſeveral powerful medicines, are the principal uſes to which this metal is applied.

MERCURY OF THE PHILOSOPHERS; and

MERCURIFICATION. I take theſe articles without alteration from the dictionary of Macquer, as the ſubject does not ſeem to require, or deſerve, any very extenſive reſearch. Alchemiſts have given the name of mercury to many other things beſides the metallic ſubſtance generally ſo called. This latter they call ordinary mercury, and value it little. We cannot preciſely ſay what they meant by their mercury, from the obſcurity of their writings, and alſo from their different deſcriptions of the matter. No term is more frequently uſed by them than this. In every page of their writings we find the words mercury, mercurification, &c. Probably they had not all the ſame idea annexed to the term philoſophical mercury. The moſt probable opinion upon this ſubject is, that this mercury is the metallic principle which Becher has called mercurial earth. See EARTH MERCURIAL.

Mercurification is an alchemical operation, by which metals are ſaid to be reduced into a fluid, heavy, opake, and ſhining liquor, like ordinary mercury; or by which the mercurial principle may be extracted from metals, and obtained in the form of quickſilver. But theſe mercurified metals, or their mercurial principle rendered ſenſible, are a kind of philoſophical mercury, which, although they reſemble ordinary mercury, are nevertheleſs ſaid, by perſons exerciſed in ſuch ſtudies, to differ from it conſiderably, by having a greater ſpecific gravity, by more effectually penetrating and diſſolving metals, by a ſtronger adheſion to theſe, and by a leſs volatility.

We may find in the books of many authors, who, though not alchemiſts, give more or leſs attention to theſe ſubjects, a great number of proceſſes for mercurification, or for obtaining mercury of metals; moſt of which are very long, laborious, confuſed, and conſequently ſubject to fail. The detail of theſe proceſſes would be too long. An account of the principal of theſe operations may be ſeen in Junker's Conſpectus Chemiæ. We ſhall only mention ſome of the eaſieſt mercurifications extracted from the moſt modern authors, as Wallerius and Teichmeyert.

If cinnabar of antimony made with corroſive ſublimate be diſtil'ed, we ſhall obtain, by reviving the mercury, a larger quantity of mercury than was originally in the corroſive ſublimate.

If a corroſive ſublimate be prepared with ſpirit of ſalt and fluid mercury, and if calx or filings of ſilver be ſeveral times ſublimed together with this corroſive ſublimate, a part of the ſilver will be changed into mercury.

Very fine filings of iron, expoſed during a year to the air, and afterwards well triturated in a mortar, and cleanſed from duſt and extraneous matter, then expoſed during another year to the air, and laſtly, diſtilled in a retort, furniſh a hard matter which attaches itſelf to the neck of the retort, and with this matter a little mercury. TEICHMEYERT.

If calx of copper be mixed with ſal ammoniac, and this mixture expoſed during a certain time to air, and diſtilled with ſoap, mercury will be obtained.

If luna cornea or plumbum corneum be mixed with an equal weight of very concentrated ſpirit of ſalt, digeſted together during three or four weeks, then an equal quantity of black flux and Venice ſoap added to it, and the whole matter diſtilled in a glaſs retort, ſome mercury will paſs into the receiver.

Theſe

Theſe experiments are important, and eaſily made, but have not been repeated by modern chemiſts; for which we ſee no other reaſon than the ſmall hopes of their ſucceeding. If they ſhould ſucceed, they would aſcertain the exiſtence of a mercurial principal in metals, and would ſo much more confirm the theory of Becher, as all the experiments above mentioned are made with the marine acid, which that chemiſt ſuppoſes to contain the mercurial earth. The concluſion deducible from theſe experiments would be, that, by introducing a ſuperabundant quantity of mercurial earth into metals, a true mercury might be obtained from them. See METALS.

Many other proceſſes for mercurification may be ſeen in authors who have treated of this matter, particularly in Junker's book above quoted, in which marine acid is not employed, but other ſaline matters, or ſublimation through the burning fuel, with concourſe of free air, in Geber's manner. In this latter caſe, we muſt look for the mercurial ſubſtance in the metallic fumes and flowers; and if any ſuch ſubſtance be obtained, it muſt evidently proceed from the decompoſition of the metallic matter employed.

Mr. Groſſe ſays, in the Memoirs of the Academy, that he obtained mercury from lead by an eaſier and ſimpler proceſs than thoſe above mentioned. This conſiſts in ſaturating perfectly ſome good nitrous acid with lead, which may be done effectually by employing more lead than the acid can diſſolve; and from this ſolution, according to Mr. Groſſe, a gray powder is precipitated, in which mercury is diſcovered. This experiment being ſhort, Meſſrs. Macquer and Beaumé repeated it with due attention in their Courſe of Chemiſtry; but they did not find the gray mercurial powder mentioned by Mr. Groſſe. As the exactneſs and veracity of that able chemiſt are well known, we muſt believe that the lead which he employed contained ſome extraneous mercury, which might eaſily happen in a laboratory. The ſame thing has poſſibly happened in other experiments of mercurification; and this proves how circumſpect we ought to be in drawing concluſions.

METALS. Metallic ſubſtances are very eaſily diſtinguiſhable from all other bodies in nature, by their very great weight, and that opake ſhining appearance which is called the metallic ſplendour or brilliancy. Very few ſubſtances have half the ſpecific gravity of the lighteſt among the metals. They are all fuſible, though at very different temperatures; and if the fuſion be made in cloſe veſſels, they fix again by cold, without having ſuffered any change but that of external figure, which muſt be produced in all bodies which have been either liquefied or volatilized; namely, they aſſume the form of the veſſel which contains them. Some of them may be extended conſiderably by the hammer, without breaking them. This property is called malleability; and the metallic bodies which poſſeſs it are called entire metals, or metals, in contra-diſtinction to ſuch as are more brittle, and are called ſemi-metals. Metallic ſubſtances are alſo called perfect and imperfect. The perfect are ſuch as undergo no laſting change of their properties by any heat we can apply to them, at leaſt, in common furnaces. The imperfect metals, when expoſed to a ſtrong heat, with acceſs of vital air, are changed, by a proceſs ſimilar to burning, and in ſome of them with an actual flame, into a brittle dull ſubſtance, called a calx, which is heavier than the metal it came from, though its ſpecific gravity is not ſo great. Some are even converted into acids. If the calx of a metal be expoſed to ſtrong heat in a cloſed veſſel, with ſome inflammable matter, it recovers its metallic ſtate. This is called reduction, or reviving of the metal.

All metals are imperfect, except gold, ſilver, and platina. The imperfect metals are, mercury, lead, copper, iron, and tin; and the ſemi-metals are, biſmuth, nickel, arſenic, cobalt, zinc, antimony, manganeſe, wolfram, molybdena, and uranite. The names arſenic, antimony, manganeſe, wolfram, and molybdena, being uſed to denote the mineral ſubſtance from which the ſemi-metals are obtained, the ſemi-metals themſelves are diſtinguiſhed by the name of regulus of arſenic, regulus of antimony, and ſo forth; though modern chemiſts often uſe the ſimple term to denote the ſemi-metal itſelf alone.

Metals, like other fuſible bodies, have each a fixed temperature, or freezing point, at which they become ſolid. They aſſume a cryſtallized figure in cooling, which is different in each, and may be ſeen by fuſing them in melting pots with a hole in the bottom ſtopped with a ſtopper; or better in many caſes, by a diſh or flat mould, and tilting it; for, in this caſe, if the ſurface be ſuffered to congeal, and the fluid metal beneath be ſuffered to run out through the hole, the under ſurface of the remaining metal will be curiouſly cryſtallized. The ſpecific gravity of metallic ſubſtances is very conſiderably affected by the gradual or haſty cooling, or tranſition from the fluid to the ſolid ſtate. Hammering renders them harder and more elaſtic; but this effect is deſtroyed by ignition.

The affinities of metals to each other are various. Some will not unite at all; others mix very readily, and even combine together. On this property is founded the art of ſoldering; which conſiſts in joining two pieces of metal together by heating them, with a thin piece or plate of a more fuſible metal interpoſed between them. Thus tin is a ſolder for lead; braſs, gold, or ſilver, are ſolders for iron, &c.

Mountainous diſtricts, where the ſurface of the globe has been thrown up or diſturbed, in remote ages, by earthquakes, volcanos, or other great convulſions of nature, are the moſt abundant in metallic bodies. In digging into the bowels of the earth, the various metals are moſtly found diſpoſed in ſtrata or beds, which in plains lie level, but in mountains are inclined; whence it happens, that in mountainous countries ſome ſtrata are often expoſed to the day, which would elſe have been too deeply lodged to be come at by human art. It is in the ſtratified mountains that metals are uſually found, moſtly in a ſtate of combination either with ſulphur or arſenic, or in the ſtate of a calx. They are alſo found, though leſs frequently, in the metallic or native ſtate.

The combinations, or earthy bodies which contain metals in ſufficient quantity to be worth extracting, are called ores. Iron ore ſometimes forms entire mountains; but in general the metallic part of a mountain is very inconſiderable in proportion to the whole. The ores run either parallel to the ſtony ſtrata, though far from having the ſame regularity of thickneſs, or they croſs the ſtrata in all directions. Theſe metallic ſtrata are called veins. The cavity formed by art in the earth, for the extraction of metals or any other mineral bodies, is called a mine. The ſtone wherein a metallic ore is uſually bedded, is called its matrix. Theſe are not peculiarly appropriated to any metal, though ſome ſtones more frequently accompany metals than others.

The general operations by which metals are obtained from ores are—1. The minerals are ſelected; and ſuch only are taken as from experience are known, by the external figure or appearance, to contain metal. 2. They are reduced to powder; and the lighter parts waſhed away, by means of water, in a ſhallow trough. 3. The volatile parts are diſſipated by the operation called roaſting. 4. The ores are ſmelted by throwing them into the midſt of the fuel of a furnace, with

with earthy ſubſtances which are diſpoſed to run into glaſs. In this operation, the glaſſy matter, called ſcoria, in ſome meaſure produces the effect of rendering the lower part of the furnace a cloſed veſſel; and the fuel revives the metal, which in the ore is uſually of the nature of calx. The revived metal being much denſer than the ſcoria, falls to the bottom, and is ſuffered to run out by proper openings. Theſe are the general operations, but they are not all neceſſary in all caſes; and the particular practice with the ſeveral ores of each metal, muſt vary according to the properties of the metal itſelf, and the different ſubſtances it is united with.

The extraction of metals from ores, in the ſmall way, which is neceſſary to be made in order to aſcertain whether the ſpecimens are worth working, is called aſſaying or eſſaying. In theſe ſmall trials, the fuſibility of the pounded ore is increaſed by an addition of black flux, which is an impure alkali, formed by mixing two parts of tartar with one of nitre, and ſetting them on fire. Metallic ores may be very accurately aſſayed by ſolution and precipitation in the humid way. See the ſeveral METALS.

The theory of the calcination and reduction of metals, according to the ſyſtem of phlogiſton, is as follows:—Metals, like all other inflammable bodies, contain phlogiſton united to a baſe. While the vital part of the air unites with the baſe, the phlogiſton is diſengaged, and leaves behind it the combination called a calx, which is heavier than the metal, becauſe the air received exceeds the weight of the phlogiſton diſengaged.—In the antiphlogiſtic ſyſtem, metals are conſidered as ſimple ſubſtances, which are converted into calces by their union with vital air, and are revived by heating them with any other matter which is more combuſtible than themſelves; that is to ſay, which has a ſtronger attraction for vital air, at the temperature of reduction. Some of the maintainers of phlogiſton admit that the vital air unites with that principle of inflammability, and compoſes a ſubſtance which combines with the baſe of the metal. Here the fact agrees with the ſtatement of the antiphlogiſtians, but the explanation is leſs ſimple.

Moſt metals will uniformly mix with each other; and the ſpecific gravity of the compound is ſeldom ſuch, as would have been deduced from the ſuppoſition of a mere mixture, or ſimple oppoſition of parts. Their fuſibility is likewiſe greatly changed by mixture, and according to no certain rule yet diſcovered.

Mixtures of metals are frequently called alloys. But the word alloy, or allay, is moſtly uſed to denote a portion of metal which is added to the precious metals, gold or ſilver.

Metals are moſtly ſoluble in acids, with which they form ſalts. When a metal is added to an acid, the general effect produced is the ſame as would have ariſen from the addition of any other combuſtible ſubſtance to the acid. If an alkali or earth be added to a metallic ſolution, the metal falls to the bottom in the form of a calx. But if a metal which has a ſtronger affinity with the acid than the metal already diſſolved has, be added to ſuch a ſolution, the former metal will fall to the bottom in its metallic ſtate, and the latter will be diſſolved without cauſing any of the eſcape of elaſtic fluid, and other appearances, which would have taken place if it had been applied to the mere acid; notwithſtanding which, the latter metal, if precipitated by an incombuſtible ſubſtance, ſuch as an alkali or earth, will be in the ſtate of a calx.

It is evident, from theſe facts, that the action of acids upon metals is ſimilar to that of heat with acceſs of vital air; and of courſe may be accounted for, upon both the theories of chemiſtry, in the ſame manner as combuſtion itſelf. Accord-

ing to the original theory, when an acid acts upon a metal, it unites with the base of the metal, and expels the phlogiston; which either rises alone, in the form of inflammable air; or, combining with the acid itself, forms an acid air, or volatile acid. If an alkali be added, the calx falls down, combined with air, which it obtains either from the alkali or the acid; but if a metal be added, the phlogiston of this last, uniting with the calx of the former, revives it, and it falls down in its metallic state. The new theory may be applied as follows: When a metal is added to an acid, it attracts vital air either from the acid itself or from the water. If the former, the acid itself is decomposed, and its base, combined with an under proportion of vital air, arises in the form of volatile acid, or acid air. But, if the latter, the water itself is decomposed, its vital air combining with the metal, and its inflammable air flying off: in this case, the acid is supposed to do nothing more than hold the calx in solution, and by that means facilitate the action of the water, which would be much less effectual if the calx were suffered, on account of its insolubility, to remain upon and defend the surface of the metal; which by reason of its insolubility as mere water, it would not fail to do, if the acid were not present.

Metals are precipitated by each other in the same order, or nearly so, in all acids. Hence it is inferred, that this effect is produced by the re-action of some common principle, either of the metal or of the acids. In the old theory, a metal which has a stronger attraction for phlogiston, will take that principle from another metal which holds it more weakly; and of course the latter will cause the former to be precipitated in its metallic form. In the new theory, a contrary transition of vital air from the acid produces the same effect: for, if a metal has a stronger attraction for vital air than is exerted by another metal already in solution, it will deprive this last of it, and cause it to fall down in the metallic state.

Acids dissolve metals only in their calciform state; and there is a certain limit near which the solution is best performed. If an acid be of such a nature as to be incapable of calcining a metal, it will not dissolve it, though the same acid would dissolve the calx if presented to it; and if the calcination be carried on too far, the calx will likewise be insoluble. To explain this according to the two theories, it may be observed, that acids calcine metals by virtue of their attraction for phlogiston, and suspend the calx by virtue of the same power exerted on the remaining portion of phlogiston, of which they cannot in general divest the calx; consequently, if the calx be divested of this portion, it will be insoluble. Or, in the other theory, the simple metal attracts as much vital air from the acid as is sufficient to convert itself into a calx, but not enough to saturate it with that principle: it is therefore suspended, in consequence of its remaining weak attraction for the vital air of the acid. But if the calcination be complete, that is to say, if the affinity of the metal for vital air be perfectly satisfied, the remaining attraction of the metal for vital air will cease, and it will be insoluble.

The direct action of alkaline salts upon metals is not considerable: sulphur combines with most of them readily in the way of fusion; and the combination of sulphur with an alkali, called liver of sulphur, is a powerful solvent of all metals except zinc. Nitre heated with metals acts in the same manner as it does with other inflammable bodies: it deflagrates, and the metals become calcined. The perfect metals resist the action of nitre.

METALLURGY. The characters from which mineralogists pretend to assert the existence of an ore in the bowels of the earth, are all equivocal and suspicious. The savage aspect of a mountain, the nature of the plants which grow

grow upon it, the exhalations which ariſe from the earth, all afford characters too doubtful for a reaſonable man to riſk his fortune upon ſuch indications alone.—The dipping wand, or divining rod, is the fruit of ſuperſtition and ignorance: and the ridicule which has been ſucceſſively thrown upon this claſs of impoſtors, has diminiſhed their number; at the ſame time that the numerous dupes of this claſs of men have rendered their ſucceſſors more prudent. It is nevertheleſs uſed in Cornwall to this day.

The nature of the ſtones which compoſe a mountain is capable of furniſhing ſome indications. We know, for example, that ores are ſeldom found in granite, and the other primitive mountains; we know likewiſe that mountains of too modern a formation contain them very rarely; and we find them only in ſecondary mountains, in which the ſchiſtus and ancient calcareous ſtone are void of all impreſſions of ſhells.

The preſence of ponderous ſpar, forming a ſtratum or vein at the ſurface of the earth, has been conſidered by many mineralogiſts as a very good indication. Chaptal ſhews very good reaſon for believing that this ſtone is the ſame which Becher has ſpoken of in his works, under the name of Vitrifiable Earth, which he conſidered as a principle of metals; and that it has been very improperly taken for quartz by his readers.

When we poſſeſs indications of the exiſtence of an ore in any place, we may uſe the borer, to confirm or deſtroy theſe ſuſpicions, at a ſmall expence.

It frequently happens that the veins are naked or uncovered: the mixture of ſtones and metals forms a kind of cement, which reſiſts the deſtructive action of time longer than the reſt of the mountain; and as theſe parts of rocks, connected by a metallic cement, preſent a ſtronger reſiſtance to the action of waters, which inceſſantly corrode and diminiſh mountains, and carry away their parts into the ſea, we frequently obſerve the veins projecting on the ſides of mountains incruſted with ſome ſlight metallic impreſſion, altered by the lapſe of time.

The nature of an ore is judged from inſpection. A ſlight acquaintance with this ſubject is ſufficient to enable the obſerver to form an immediate judgment of the nature of an ore. The blow-pipe is an inſtrument by the aſſiſtance of which we may in a ſhort time become acquainted likewiſe with the ſpecies of the ore. See BLOW-PIPE. This knowledge forms the docimaſtic art, or docimaſia. In order to make the aſſay of an ore, in general, for all ores do not require the ſame proceſs, ſmall pieces of the mineral are examined. Theſe are cleared from foreign and ſtony ſubſtances as much as poſſible. The pure mineral is then pounded, and a certain quantity weighed, which is torrified in a veſſel larger and leſs deep than a common crucible. By this means the ſulphur, or the arſenic in combination with the metal, is diſſipated; and by the loſs of weight reſulting from the calcination, a judgment is formed of the proportion of foreign volatile matter it contained.

This firſt operation ſhews the proportion and quantity of ſulphur and arſenic which may be mixed with the metal. The ſulphureous ſmell may eaſily be diſtinguiſhed from the ſmell of garlic, which characterizes arſenic. Theſe foreign ſubſtances mixed with the metal are called mineralizers.

In order to obtain an accurate judgment of the weight of the mineralizer, the augmentation in weight which the metal has undergone in paſſing from its metallic ſtate to that of oxide or calx, muſt be added to the loſs occaſioned by the calcination.

Two hundred grains of this roaſted ore are then to be taken, and mixed with

fluxes

fluxes capable of fuſing and reducing it. In this operation a crucible is made uſe of; and a ſufficient degree of heat being applied, the metal is precipitated to the bottom of the crucible in a button, whoſe weight indicates the quantity of metal contained in the ore.

Theſe fluxes muſt be varied according to the nature of the ores under examination. It is neceſſary that they ſhould all contain the coaly principle, to diſengage the vital air with which theſe metals are impregnated by the calcination. But the nature of the flux muſt be varied according to the fuſibility of the metal. The three following will anſwer all theſe purpoſes:

1. The fuſible material called black flux is made with two parts of tartar, and one part of nitre, melted together. The coaly and alkaline reſidue is uſed to reduce the ores of lead, copper, antimony, &c.

2. Two hundred grains of calcined borax, one hundred grains of nitre, twenty grains of ſlaked lime, and one hundred grains of the ore intended to be aſſayed, form the flux of Scopoli, which Chaptal found advantageous in the aſſay of iron ores.

The vitreous flux of M. de Morveau, made with eight parts of pounded glaſs, one of borax, and half a part of powder of charcoal, may be employed for the ſame purpoſe.

3. Arſenic and nitre, in equal parts, form likewiſe a very active flux.

The neutral arſenical ſalt has been uſed with ſucceſs to fuſe platina.

As ſoon as the exiſtence of a mine, and its nature and riches are aſcertained, it is in the next place neceſſary to be aſſured of a ſufficient abundance and continuity of water to anſwer the purpoſes of the works. It is likewiſe neceſſary to be aſſured of poſſeſſing a ſufficient quantity of wood or charcoal, and more eſpecially, a good director muſt be procured: for a poor mine well managed is preferable to a rich one ill conducted.

Theſe preliminary circumſtances being accompliſhed, the moſt ſimple and leaſt expenſive proceſſes muſt be employed in extracting the mineral from the bowels of the earth. For this purpoſe, ſhafts or galleries muſt be dug, according to the poſition of the vein, and the nature of its ſituation.

When it is practicable to arrive at the ſide of the vein, and at a certain depth, by a horizontal gallery, the works become more ſimple and œconomical; the ſame opening ſerving to draw off the waters, and extract the ore. Galleries are then to be carried on to the right and left; and ſhafts ſunk, which communicate with the open air, as likewiſe others carried down into the vein. Galleries are likewiſe conſtructed, one above the other, and the communication of the works kept up by ladders. When the ſoil is friable, and defective in ſolidity, care muſt be taken to ſupport it with timbers of ſufficient ſtrength, to prevent its falling in.

Pickaxes, wedges, and levers are uſed to detach the ore, when the rock is ſoft; but it is moſt commonly neceſſary to employ gunpowder.

Want of air, and the abundance of water, are almoſt always noxious, and derange mine-works. The water is carried off by fire-engines, wind-mill pumps, and other ſuitable apparatus.

Currents of air are produced by eſtabliſhing communications with the galleries, by horizontal apertures. Furnaces erected on the ſide of a ſhaft, to which a long tube is adapted at one end, communicating with the aſh-hole, and at the other plunging into the ſhaft to draw up the air, or ventilators placed in the ſame ſituation anſwer a ſimilar purpoſe. The foul air is deſtroyed by rendering a lixivium of aſhes cauſtic; and ſprinkling quick lime about the mine likewiſe produces the ſame effect.

A pru-

A prudent company ought to extract the largeſt poſſible quantity of ore, before they determine upon conſtructing the neceſſary works for the ſubſequent proceſſes. We cannot ſee into the bowels of the earth. Appearances are often deceitful; and we have ſeen companies either ruined or diſcouraged, becauſe they had employed immenſe ſums to conſtruct the neceſſary furnaces to work an ore whoſe exiſtence was doubtful. When the proceedings, in an undertaking of this kind, are carried on with proper precaution, and no more expence is entered into than what the ore extracted, and of a known value, is capable of repreſenting, the probable loſſes are very ſlight, even in the pooreſt mine.

The works ought to be varied according to the nature and ſtate of the mineral. It is found in three ſtates:—1. In the form of a native metal: in this caſe, nothing more is neceſſary than to extract it out of the mine, to clear it of the extraneous ſubſtances, and to fuſe it. 2. In the form of calx: and in this ſtate it is ſufficient if it be ſorted and fuſed. 3. Combined with ſulphur or arſenic, in which caſe it muſt be made to undergo ſome other operations.

Although, in this laſt caſe, the works, ſubſequent to the extraction, vary according to the nature of the ore, there are nevertheleſs certain general operations to which every kind of ore is ſubjected.

The firſt buſineſs muſt be to clear the metal of the ſtony matter or matrix. For this purpoſe, when the ore is extracted, children are employed who examine it, and ſeparate the pure ore, or rich mineral, from that which is mixed with the gangue. As in this ſecond quality the ſtone is mixed with the ore, the whole is pulverized by means of a ſtamping mill, conſiſting of peſtles of wood, ſhod with iron, and armed with cocks, which are raiſed by levers proceeding from the axis of a wheel that conſtantly turns. The mineral is by this means cruſhed and pulverized; and a ſtream of water, which is made to paſs over it, carries away both the metallic and ſtony particles; the former being depoſited in the firſt veſſels through which the water is made to circulate, while the latter, or ſtony part, is carried to a greater diſtance, on account of its lightneſs.

This pulverized ore is called ſclich; and in order to ſeparate all the earthy parts, it is waſhed upon tables ſlightly inclined, over which a conſtant ſtream of water is made to flow. The ſclich is agitated with brooms; the water carries away all the fragments of ſtone, and leaves the pure ore upon the table.

The calcination of the mineral ſucceeds the waſhing. In this operation, the mineralizer is carried off. Fire is always the agent made uſe of. Sometimes the pounded mineral is diſpoſed in piles upon heaps of wood, which being ſet on fire, heat the ore ſtrongly, and drive off the mineralizer. This calcination poſſeſſes the double advantage of diſpoſing the metal for fuſion, as well as clearing it of the mineralizing ſubſtance. When the ore is more friable, it is ſpread out in a reverberatory furnace; and the flame which reverberates upon it deprives it of its mineralizer, at the ſame time that it partly fuſes it.

M. Exchaquet has propoſed to deſtroy the ſulphur by nitre in aſſays. This proceſs is excellent for copper ores: the quantity of nitre varies according to the quantity of ſulphur; but there is no danger of adding too much. In this operation the mixture is thrown into an ignited crucible, and kept at a moderate heat for ſome minutes.

The fuſion is effected in furnaces, excited by a current of air, kept up by means of large bellows, or a machine called a trompe. See TROMPE.

METEORS, and

METEOROLOGY. The ſtate and condition of the great fluid maſs, in which we breathe, and the changes which take place therein, are objects of no

ſmall importance to the chemical philoſopher. Among the variety of experiments on permanently elaſtic fluids, it is found that moſt of them are capable of uniformly mixing together, when their nature is ſuch as not to act perceptibly upon each other. But in the extenſive maſs of the atmoſphere, it ſeems likely that conſiderable ſeparations of its component parts take place in conſequence of their different ſpecific gravities. This ſuppoſition is countenanced by ſeveral optical phænomena, ſuch as the double appearance of head lands. In this way ſome writers account for the appearance of the aurora-borealis, ſhooting ſtars, and other ſimilar appearances, which they ſuppoſe to conſiſt of inflammable air, occupying the upper region of the atmoſphere, and fired by electricity. It is a remarkable circumſtance, that moſt of theſe fiery appearances happen at an elevation, which is geometrically determined to be almoſt twice as great as that which aſtronomical writers, by deductions founded on the refraction of the light of the heavenly bodies, and the law of dilatation of air near the ſurface of the earth, have aſſigned as the ſenſible limit of the atmoſphere. Hence it ſhould follow, that the elaſticity of the upper parts exceeds that of the lower; which affords no inconſiderable preſumption that this upper part is chiefly compoſed of ſuch air as we know to be the moſt elaſtic, namely, the inflammable. The compoſition of water out of the two ingredients, vital and inflammable air, has alſo afforded ground for meteorological induction. It has been concluded, that water is not only condenſed and precipitated by the agency of electricity, in thunder ſtorms, but that it is likewiſe compoſed out of its elements by the combuſtion of theſe two airs in every caſe where atmoſpherical corruſcation is exhibited.

The phænomena of winds, though chiefly depending on the hydroſtatical change in the denſity of the air by alteration of temperature, well deſerve the attention of the chemiſt. The effect of furnaces, the clearingof laboratories, burial vaults, houſes of office, mines, and other excavations, from noxious effluvia, are all governed by general laws of the ſame nature as thoſe which cauſe the currents of air around us. Even the ſudden and frequently impetuous current of air which accompanies a fall of rain, or ſquall, though it be merely produced by the mechanical action of the falling drops of water, has afforded ground for uſeful meditation. There is no doubt but we are indebted to conſiderations on this natural appearance for the cheap and uſeful blowing-machine, which the French call a trompe. See TROMPE.

It may ſeem at the firſt ſight, as if obſervations on the ſtanding of the barometer and thermometer were of no very immediate uſe to the practical chemiſt. But if it be conſidered, that the effect of an air furnace depends on the difference of the denſity of the air in the chimney, and that which enters the aſh-hole; and that the mere difference indicated by the barometer, amounts to one fifteenth part in its extremes of the whole quantity of the external air, in a given place, not to mention the effect pointed out by the thermometer, it will not appear ſtrange that theſe cauſes ſhould greatly influence the reſults in metallurgical operations, and be very perceptible in the burning of our culinary fires. The philoſophical chemiſt is no leſs intereſted in the ſtate of the air, as ſhewn by theſe inſtruments. For it cannot but be of great conſequence to his deductions, to know the external preſſure which is conſtantly acting upon the elaſtic fluids he may either weigh or meaſure. If this and the temperature be not carefully attended to, he will ſcarcely find any two reſults, made at diſtant times, agree.

The preſence of moiſture, or rather its diſpoſition to be abſorbed, or given out, as ſhewn by the hygrometer, muſt be of conſiderable importance. It affects the elaſticity of every kind of air, and there is no doubt but combuſtion and its pro-

ducts will vary accordingly as it is maintained by an air which is moister or more dry. It is probable that the quantities of finery cinder afforded by iron may vary from this cause.

The effects of solution and precipitation analogous to what happens in denser fluids, have been, perhaps too fancifully, delineated among the atmospheric changes. But there is every reason to think, that as our knowledge of the great system of nature shall improve, the play of the chemical affinities will shew itself more evidently in the atmosphere.

METHEGLIN. A fermented beverage made from honey.

MICA. This stone in its purest state is colourless; but either from a less intimate combination, or from a mixture of some superfluous ingredient, principally iron, it is found of different colours, white, red, yellow, green, brown, or black (the white and yellow sort have a splendid metallic appearance), smooth, but not greasy to the touch, which distinguishes it from talc. Its texture is always lamellar or scaly, and the lamellæ, or scales, are slightly flexible and often elastic; these scales are sometimes parallel to each other, sometimes interwoven, sometimes wavy or undulated, and sometimes they represent filaments. Its specific gravity is from 2.535 to 3.000, when loaded with iron.

It does not effervesce with acids, and is insoluble in them without particular management; but after it has been calcined with four times its weight of fixed alkali, it effervesces strongly, and is in great measure soluble.

The pure colourless mica is infusible *per se*, and scarcely melts even with mineral alkali, but yields more readily to borax or microcosmic salt, with scarce any effervescence; but the coloured sorts were found by M. Saussure to be fusible *per se*, though with difficulty, for they require a stronger heat than shoerl does.

One hundred parts of the colourless kind contain 38 of silex, 28 of argill, 20 of magnesia, and 14 of the most dephlogisticated calx of iron. Martial mica contains besides, 10 or 12 per cent. of a more phlogisticated calx of iron, from whence its various colours are derived, and a proportionably smaller quantity of the other ingredients.

MICROCOSMIC SALT. A triple salt obtained from urine, and much used in assays by the blow-pipe, under this name. The method of extracting it according to Weigleb is as follows:—A large quantity of urine, either fresh or putrid, is evaporated to the consistence of a thin syrup. The vessel is then set by in a cool place, and in the space of a month the microcosmic salt separates in the form of prismatic crystals, of a slightly saline taste and reddish brown colour. The remaining liquor being decanted, these crystals are again dissolved in as much warm water as is requisite, and the filtered liquor is immediately set in a cooler place, whence in the space of five days finer and purer crystals are obtained. These may afterwards be dissolved once more in warm water, filtered and crystallized till they have acquired the requisite whiteness. The quantity thus obtained is very small. As the phosphoric acid is now easily to be procured or made, it would probably answer the purpose of the chemical philosopher better, to use the pure combination of phosphoric acid, and volatile alkali made in the direct way. This salt does not crystallize unless there be a slight access of alkali.

MILD ALKALIS, OR EARTHS. The alkalis and lime are usually met with in combination with fixed air. Heat expels this substance from lime, and the alkalis are deprived of it by the superior attraction of pure quick lime, with which they are treated for that purpose. These practical operations were made long before the existence and properties of fixed air were well ascertained. The

alkalis and lime, when combined with fixed air, obtained the name of mild, from their ſlight action upon organized ſubſtances, compared with their action when deprived of it. In this laſt ſtate, they were ſaid to be cauſtic. The terms cauſtic and mild are ſtill frequently applied to the alkalis, and alſo to lime, magneſia, and ponderous earth.

MILK is a well known fluid, ſecreted in peculiar veſſels of the females of the human ſpecies, of quadrupeds, and of cetaceous animals, and deſtined for the purpoſe of nouriſhing their young. Its appearance and component parts are not altogether the ſame in various ſpecies of animals; but the differences have not yet been well aſcertained. For this reaſon, in treating of milk, our attention will be confined to that of the cow, becauſe the moſt abundantly met with. This fluid is of a beautiful opake white colour, nearly as limpid as water, and of a pleaſant emulſive taſte. Its appearance on the ſtage of a microſcope exhibits an infinity of minute opake globules floating in a tranſparent fluid.

Cow's milk, diſtilled on a water bath, affords a taſteleſs phlegm of a faint ſmell, which is capable of putrefying. A ſtronger heat coagulates it. It is ſometimes gradually dried into a ſubſtance which is a kind of ſaccharine extract, and may again be diffuſed in water. By deſtructive diſtillation, milk affords an acid, a fluid oil, a concrete oil, and volatile alkali. Its reſidual coal contains a ſmall quantity of vegetable alkali, ſome ſalt of Sylvius, and phoſphoric calcareous ſalt.

When milk is left to ſpontaneous decompoſition, at a due temperature, it is found to be capable of paſſing through the vinous, acetous, and putrefactive fermentations. It appears however, probably on account of the ſmall quantity of ardent ſpirit it contains, that the vinous fermentation laſts a very ſhort time, and can ſcarcely be made to take place in every part of the fluid at once by the addition of any ferment. This ſeems to be the reaſon why the Tartars, who make a fermented wine from mare's milk, called koumiſs, ſucceed by uſing large quantities at a time, and agitating it very frequently.

The coagulation of milk, in the manufacture of cheeſe, is effected by the addition of rennet, which is the infuſion of the ſtomach of a ſucking calf in water, prepared in various ways, according to the fancy of the makers. This fluid ſeems to owe its properties to the gaſtric juice of the animal. The ſeparated curd is wrapped in a cloth with ſalt, and preſſed, to deprive it of the ſuperfluous whey; after which, it is preſerved for ſeveral months or years before it is conſidered as fit for uſe.

Cheeſe, when decompoſed by deſtructive diſtillation, affords an alkaline phlegm, an heavy oil, and much volatile alkali. Its reſidual coal is difficult to incinerate, and does not afford fixed alkali. By treating it with the nitrous acid, it is found to contain lime and phoſphoric acid. Cheeſe is not ſoluble in water. Hot water hardens it.

The ſaccharine ſubſtance upon which the fermenting property of milk depends, is held in ſolution by the whey which remains after the ſeparation of the curd in making cheeſe. This is ſeparated by evaporation in the large way, for pharmaceutical purpoſes, in various parts of Switzerland. When the whey has been evaporated by heat, to the conſiſtence of honey, it is poured into proper moulds, and expoſed to dry in the ſun. If this crude ſugar of milk be diſſolved in water, clarified with whites of eggs, and evaporated to the conſiſtence of ſyrup, white cryſtals, in the form of rhomboidal parallelopipedons, are obtained.

Sugar of milk has a faint ſaccharine taſte, and is ſoluble in three or four parts of

of water. It yields by diſtillation the very ſame products that other ſugars do. It is remarkable, however, that the empyreumatic oil has a ſmell reſembling flowers of benzoin. Twelve ounces of diluted nitrous acid being poured upon four ounces of finely powdered ſugar of milk, in a glaſs retort, on a ſand-bath, with a receiver annexed, the mixture became gradually hot, and at length effervеſced violently, and continued to do ſo for a conſiderable time after the retort was taken from the fire. It is neceſſary therefore, in making the experiment, to uſe a large retort, and not to lute the receiver too tight to the retort. After the efferveſcence had in ſome meaſure ſubſided, the retort was again placed on the ſand-bath, and the nitrous acid diſtilled off, till the maſs acquired a yellowiſh colour. This yellow fluid exhibited no cryſtals. Eight ounces more of the ſame nitrous acid were therefore added, and the diſtillation again repeated, till the yellow colour of the fluid diſappeared. The fluid became inſpiſſated by cooling; it was therefore re-diſſolved in eight ounces of water, and filtered. Seven drams and a half of a white powder remained on the filter, and the clear ſolution afforded cryſtals of ſaccharine acid. The mother water was again treated ſeveral times with nitrous acid, by which means the whole was at length changed into ſaccharine acid.

The white powder that remained on the filter was found to be combuſtible, like oil in a red hot crucible, without leaving any mark of aſhes behind. It was ſoluble in ſixty times its weight of boiling water; and one fourth part ſeparated by cooling, in the form of very ſmall cryſtals. The remaining maſs being then collected, by evaporating the greateſt part of the water, left behind a ſmall portion of the acid of ſugar, of which it had not been ſo exactly deprived by edulcoration on the filter. From theſe circumſtances it appeared, that the white matter was a ſalt; and, upon examination, it was found to be an acid poſſeſſing the following properties:

With all the ſoluble earths, it forms ſalts inſoluble in water. It diſengages fixed air from the mild alkalis. With vegetable alkali it forms a cryſtallizable ſalt, ſoluble in eight times its quantity of boiling water, and ſeparable for the moſt part by cooling. With the mineral alkali it forms a ſalt, which requires only five parts of boiling water for its ſolution. Both theſe ſalts are perfectly neutral. When ſaturated with volatile alkali it forms a ſalt, which, after being gently dried, has a ſouriſh taſte. It does not perceptibly act on the metals; but, forms with their calces, in ſolution, ſalts of very difficult ſolubility, which are therefore precipitated*.

The principles of milk appear to be united together partly in a chemical, and partly in a mechanical manner; and the butter ſeems to riſe to the top, in conſequence of the greater ſpecific gravity of the whey through which it is diſperſed. Cream conſiſts of butter mixed with much whey and curd. It is generally thought that the ſeparation of the butter by churning, is effected ſimply by the agitation, which cauſes the fatty particles to ſtrike againſt each other, and coagulate into larger maſſes. There ſeems, however, ſome reaſon to think that a chemical effect takes place in this operation; in which, the intimate mixture of atmoſpheric air with the fluid may perhaps have ſome effect.

Butter appears to be of the nature of fat oils; but is conſidered by moſt nations as infinitely preferable to them, as an article of food. By diſtillation on a

* On milk and its acid, and on the acid of the ſugar of milk, conſult the Chemical Eſſays of Scheele.

water-bath it gives out the aqueous fluid, which, from the manner of its fabrication, is diſtributed through its maſs. Its products by deſtructive diſtillation nearly reſemble thoſe of other oils. They conſiſt of an acid of a ſtrong and penetrating ſmell, a fluid oil, and a concrete oil of the ſame ſmell as the acid. Theſe oils, like others obtained in ſimilar circumſtances, may, by repeated rectifications, be converted into volatile oils, of the nature of thoſe which are called eſſential. In other reſpects, butter poſſeſſes the ſame properties, and may be applied to the ſame uſes as fat oils. It becomes rancid by ſpontaneous decompoſition, which develops its acid; and with fixed alkalis it forms ſoap.

The eggs of birds conſiderably reſemble milk in their component parts, though their peculiar ſtructure and organization conſtitute a great and eſſential difference, applicable to the purpoſes of generation, into which our preſent views do not require us to proceed. The white of egg does not greatly differ from the curd of milk or cheeſe. When it is mixed with water, it forms a coagulum or curd by the addition of acids. Heat coagulates the white of egg, without depriving it of weight; which is a very ſingular fact, and has not yet been well explained. The white of egg, however, appears to differ, in ſome reſpects, from curd. It is ſaid to afford a ſmall portion of ſulphur by ſublimation; and it contains the mineral alkali in a diſengaged ſtate.

The yolk of egg appears to be an animal emulſion, which is diffuſible in water. It contains an oil, which may be ſeparated by drying, and afterwards ſubjecting it to preſſure. See Acid of Milk, Butter, and Cheese.

MILLIPEDES. The millipedes, aſelli, porcelli, oniſci, &c. preſented certain peculiar circumſtances in their analyſis, made by M. Thouvenel. By diſtillation on the water-bath, without addition, they afford an inſipid and alkaline phlegm, ſometimes effervеſcing with acid, and converting the ſyrup of violets to a green: in this operation they loſt five-eighths of their weight. By treatment with water and ſpirit of wine, they afterwards afforded two drachms of ſoluble matter in the ounce; of which more than two thirds were extractive matter, and the reſidue an oily or extractive ſubſtance. Theſe two matters were eaſily ſeparated by ether, which diſſolves the latter without touching the extract; they differ from thoſe of cantharides, and ants, in affording more concrete volatile alkali, and no acid in their diſtillation. M. Thouvenel obſerves, on this ſubject, that among inſects the millipedes appear to have the ſame relation to cantharides and ants, which reptiles have with reſpect to quadrupeds.

The neutral ſalts contained in theſe inſects are very ſmall in quantity, and very difficult to be extracted. M. Thouvenel affirms, that the millipedes, earth-worms, and lumbrici, conſtantly afforded him marine ſalt, with earthy baſes, and baſe of vegetable alkali; while in ants and cantharides, theſe two baſes, the firſt of which always appeared to him the moſt abundant, are united with an acid, which has the character of the phoſphoric acid. It is neceſſary to be obſerved here, that this chemiſt, in his Diſſertation, has not deſcribed either the methods of extracting theſe ſalts, or the proceſſes he made uſe of to aſcertain their nature.

MINERALOGY and MINERALS. Every ſubſtance which does not poſſeſs organization, or is not the immediate product of ſome organiſed body, belongs to the mineral kingdom. Among the numerous variety of materials which demand the attention and exerciſe the ingenuity of the chemiſt and the manufacturer, ſome are compounded of ſuch principles, and formed under ſuch circumſtances and ſituations in the earth, that it is difficult to diſtinguiſh them without recurring to the teſt of experiment. Others are formed with conſiderable

regularity

regularity as to the proportion of their principles, their colour, fracture, ſpecific gravity, and cryſtallized figure. Every practical mineralogiſt is naturally diſpoſed to avail himſelf of the external figure and obvious characters of bodies, to diſtinguiſh them from each other, and we daily ſee inſtances of great ſkill in this method of diſcrimination. It happens unfortunately however for the acquiſition of this branch of knowledge, that the differences depend upon circumſtances, which, for the moſt part, are ſcarcely communicable by mere deſcription, without the exhibition of ſpecimens. Hence it has in many inſtances happened, that chemiſts have obtained poſſeſſion of quantities of minerals, the names of which they could not with any degree of certainty aſcertain, until they had made ſome experiments to determine their component parts. Much induſtry has been employed with ſucceſs in ſimplifying the experiments with re-agents, and with the blow-pipe, for this purpoſe. Thus it has ariſen that mineralogy has been aſſiduouſly cultivated by two different deſcriptions of men. The one have noted the figures, meaſured the angles, deſcribed the colours, tranſparency, opacity, texture as aſcertained by fracture, hardneſs, and the like evident properties; the other have paſſed ſlightly over theſe indications, and have attended chiefly to ſuch component parts, as chemical analyſis exhibits. The beſt ſyſtem for the claſſification of minerals muſt be that in which the external characters, as well as the component parts, are noticed; for there is no reaſon why we ſhould neglect any of the means of obtaining an accurate knowledge of bodies. The component parts or principles of minerals afford the great outlines for claſſing them under general ſpecies and varieties; and their external appearances, when not ſufficiently deciſive to the obſerver, will always be uſeful to point out the experiments he muſt make to aſcertain their place. The modern ſyſtems of Bergman, Kirwan, and Chaptal, are grounded on conſiderations of this nature*. See ANALYSIS and BLOW-PIPE.

MINERALIZER. Metallic ſubſtances are ſaid to be mineralized when deprived of their uſual properties by combination with ſome other ſubſtance. The commoneſt mineralizers are ſulphur, arſenic, and fixed air. Vital air is as common as any, but is not uſually reckoned among mineralizers, on account of the phlogiſtic theory, which, in a great meaſure, overlooks the agency of this ſubſtance in calcination. Arſenic is likewiſe excluded from mineralizers, by ſome writers, who affirm that it is always united to metals in its metallic ſtate. But as there are good reaſons to conclude that it exiſts in ſuch combinations in the form of calx or acid, the argument cannot be admitted as concluſive. The vitriolic and marine acids are leſs common mineralizers. The phoſphoric acid exiſts in the green lead ore, and leſs evidently in ſome of the ores of iron. Fixed air exiſts in the calciform ores.

MINES. See METALLURGY.

MINIUM. Red lead, or minium, may be made directly from lead, and alſo from litharge, which can be had cheaper from various proceſſes where lead is employed. But this laſt red lead is not ſo good as the former, on account of the

* For general ſyſtems of mineralogy the Engliſh reader may recur to the following works: Cronſtedt's Eſſay towards a Syſtem of Mineralogy, edited by Magellan, in two vols. octavo. Kirwan's Elements of Mineralogy. Outlines of Mineralogy, by Bergman; Mongez has re-publiſhed this work in French, with very large additions; but, unfortunately for ſcience, it is not tranſlated, and of courſe not eaſily obtained in this country. The Mineralogical Syſtem of Daubenton is inſerted entire in Fourcroy's Elements of Natural Hiſtory and Chemiſtry. And a conciſe ſyſtem, of later date than theſe, may be found in the ſecond volume of Chaptal's Chemiſtry.

ſcoria of other ſubſtances mixed with the litharge. The makers of flint glaſs, who uſe much red lead in the compoſition of that glaſs, find that it does not flux ſo well as that made from the direct calcination of the metal, as practiſed in the county of Derby, where no leſs than nine mills, or furnaces, are kept on this operation. Theſe furnaces are very like a baker's oven, with a low vaulted roof, and two party walls, riſing from their floor, which leave a middle ſpace, where the pit coal is burned: the flame being drawn over the party walls, ſtrikes on the roof, and is from thence reflected on each ſide, by which the lead there kept is melted. The ſurface of lead, by its expoſition to air, becomes inſtantly covered with a duſky pellicle; this is ſucceſſively removed, and the greateſt part of the metal is converted into a yellowiſh green powder: this is afterwards ground fine in a mill, and waſhed; the heterogeneous particles of lead, ſtill in being, are ſeparated by paſſing the waſh through ſieves; the yellow colour becomes uniform, and is called maſſicot by the painters. Theſe yellow calces being well dried, are thrown again into the furnace, where they are conſtantly ſtirred in a continued heat; ſo that in about 48 hours, theſe calces acquire a vivid red, inclining to orange colour, and are known by the name of minium, or red lead. M. de Machy was certainly miſtaken, when he aſſerted that the calcination alone, without the contact of the flame and ſmoke, was capable of producing a good colour. But the red lead made in France is of a conſiderably worſe quality than what is made in England or Holland. A ton, or twenty hundred weight, of lead generally gives twenty-two hundred weight of minium. It is ſaid, that at Nuremberg the increaſed weight of red lead amounts to one-fifth of the metal; this may probably depend on the method employed, as Watſon thinks. Neumann ſays, that the beſt Venetian minium is made out of ceruſſe, or white lead. Magellan.

MIRABILE SAL. Glauber's ſalt, or the combination of vitriolic acid with the mineral alkali, has been pretty generally known by the name of ſal mirabile Glauberi, who obtained it from the reſidue, after diſtilling marine acid from a mixture of common ſalt and the acid of vitriol.

MIRACLE CHEMICAL. If to a concentrated ſolution of Epſom ſalt, or the combinations of magneſia with the nitrous or marine acid, a like ſolution of fixed alkali be added, the magneſia is ſeparated immediately in ſo large a quantity that the mixture becomes nearly ſolid. This ſudden converſion of two fluids into a ſolid has been called the chemical miracle.

MIRRORS. See SPECULUM; alſo SILVERING.

MISPICKEL. An ore of iron conſiſting of that metal mineralized by arſenic. It is called ſpeiſs by the Bohemians. Its colour is generally of a bright white, reſembling a mixture of ſilver and tin, ſometimes, though ſeldom, variegated like a pigeon's neck, and is not eaſily altered by expoſure to the air. Its form is either granular, cuſpidated, cuneiform, priſmatic, or rhomboidal. It is magnetic neither before nor after calcination, is ſoluble in acids, affords arſenic by diſtillation in the proportion of 30 or 40 per cent. and ſometimes contains a ſmall proportion of copper and ſilver. It is frequently mixed with other metallic ores, and often found in indurated clay, quartz, ſpar, ſhoerl, &c.

When iron contains leſs than one-ſixteenth of arſenic, it is magnetic; therefore, if the calcination be puſhed ſo far, the iron will remain magnetic. It may be analyſed by ſolution in the marine acid, which will take up the iron, and leave the arſenic; or by ſolution in aqua regia, which will take up both; but water being added, will precipitate the arſenic and leave the iron. The ſilver will remain in

the form of horn ſilver, and the copper may be ſeparated by the methods mentioned under that article.

MIXTURE. This term was formerly uſed to denote what chemiſts now mean by combination. At preſent it is applied to diſtinguiſh that aggregation which takes place when powders or liquids, not diſpoſed to combine from defect of temperature, or any other cauſe, are added together. Thus ſand and an alkali may be mixed together, without any perceptible combination or change of their reſpective properties; but if the temperature be raiſed to that of ſtrong fuſion, they combine, and form glaſs, the principles of which are no longer in a ſtate of mere mixture.

MOCHA OR MOCHO STONE. The achate, when it contains arborization, or ſmall figures of trees or moſs, is called the mocho ſtone.

MOCK LEAD. An ore of zinc. See BLENDE.

MOLYBDENA, like manganeſe and wolfram, has not been reduced into maſſes of any conſiderable magnitude; but has been obtained only in ſmall ſeparate globules, in a blackiſh brilliant maſs. It has been revived by a proceſs ſimilar to that by which regulus of manganeſe (ſee MANGANESE) is obtained; but it requires a moſt extreme degree of heat for that purpoſe. The globules are grey, brittle, and extremely infuſible. By heat it is converted into a white calx, which riſes in brilliant needle-formed flowers, like thoſe of antimony. Nitrous acid readily calcines and acidifies the regulus. Nitre detonates with it, and the remaining alkali combines with its calx.

Detonation with nitre decompoſes the native molybdena; but ſolution in nitrous acid is the readieſt way to procure the acid of this ſubſtance. Pruſſian alkali, and alſo infuſion of galls, precipitate the acid from its ſolutions. When acid of arſenic is heated with molybdena, it converts part of the ſulphur into volatile vitriolic acid; which comes over, and combines with another portion, with which it riſes in the form of orpiment. No other acids but the nitrous and arſenical have any action on crude molybdena. The regulus of molybdena unites with ſeveral of the metals, and forms brittle or friable compounds.

This mineral is ſcarce. It is diſtinguiſhable from black lead by its more ſhining ſcaly appearance, and marks paper with a more brilliant ſtroke; and, as it reſembles no other ſubſtance, it does not require to be aſſayed.

MOON STONE. The moon ſtone is of a clear white colour, approaching to that of milk. When looked at in a certain poſition, it reflects a ſtrong light, like the mother of pearl; and ſome ſpecimens exhibit ſpots of a carnation colour. It is found in obtuſe-angular pieces, which ſometimes have a quadrangular figure. Its fracture is evidently foliated. It is very hard, and in other reſpects agrees with common feltſpar. Probably it is the androdamas of Pliny; the common giraſole of the Italians; and the water opal of Ceylon. It is ſometimes claſſed with the opal, and by others with the cat's-eye.

This ſtone is of the chalcedony or pſeudo-opal kind; it reflects a whitiſh light, with ſome various ſhades of a few intermixed colours on a blueiſh bottom, like the ſhining face of the moon, when it is high enough not to become reddiſh by the interference of the earthy vapours.

The rainbow-ſtone, or iris, ſeems to be nothing elſe than a moon-ſtone, in which the yellow, purple, and blue reflected rays are the moſt conſpicuous. Magellan.

MOOR-STONE. See GRANITE.

MORTAR. See LIME. Alſo a well-known inſtrument for pulverizing.

MOSAIC GOLD. See AURUM MUSIVUM. Alſo TIN.

MOSS. See ARCHIL.

MOTHER WATER, OR MOTHER LEY. When ſea-water, or any other ſolution containing various ſalts, is evaporated, and the cryſtals taken out; there always remains a fluid containing deliqueſcent ſalts, and the impurities if preſent. This is called the mother-water, and requires to be variouſly treated according to the nature of its contents. Inflammable matters are deſtroyed by evaporation to dryneſs and ignition in an open veſſel. The ſaline matters may be afterwards taken up by the addition of pure water. In other inſtances the mother-water is largely diluted, and ſuch additions made as may either precipitate part of its contents, or form ſuch new combinations as the operator is deſirous of procuring. See MAGNESIA; alſo ANALYSIS.

MOULD. See ARABLE LAND, EARTH VEGETABLE, and MARLE.

MOUNTAIN. When we contemplate the ſurface of the globe in populous diſtricts, our attention is chiefly directed to the agency of man, and thoſe energies of ſocial life, which produce, modify, and change the proſpect around us. But when we enter the wild and romantic ſcene of a mountainous country, we are every where ſtruck with the veſtiges of operations carried on by the powers of nature, through a long ſeries of ages, and upon a ſcale prodigiouſly greater than any to which the works of man can be extended. We meditate on the ſurrounding ſcene with an emotion reſembling that produced by the view of a pile of ruins long ſince gone to decay. We endeavour to inveſtigate what may have been the original ſtate of the pile, and, for want of information, our concluſions are for the moſt part little better founded than thoſe of an amuſing reverie. If the life of man had permitted the philoſopher to follow, during the revolution of centuries, that variety of changes produced on the ſurface of the earth by the numerous agents which alter it, we ſhould at this time have been in poſſeſſion of the moſt valuable information reſpecting theſe great phænomena: but confined as we are to a ſmall ſpot of the univerſe, we fix our attention for the tranſient moment of our exiſtence upon operations of prodigious duration, far remote from their commencement, or termination. It is no wonder then that, in many inſtances, we find it difficult to comprehend, and in many more to imitate, theſe vaſt proceſſes.

In whatever manner the original formation of this globe may have been accompliſhed; by what proceſſes of fire, or water, it may have been chiefly modified; to what ſecondary circumſtances its particular place in the ſolar ſyſtem, and its great movements, may be owing;—theſe ſubjects have employed the pens of religious writers, as well as of the bold conſtructors of imaginary ſyſtems. It is but too eaſy to accommodate facts imperfectly known to a favourite hypotheſis: but it becomes the philoſopher rather to analyſe than to combine too haſtily; and though knowledge may be conſidered as the claſſification of facts, it is certain that too much haſte in this claſſifying is productive of error. The inveſtigator of natural appearances ought not to be impatient under a ſtate of doubt and obſcurity. The firſt ſtep to ſolid knowledge is to conſider what now exiſts, and thence to deduce what may have heretofore exiſted.

It appears, from a great variety of obſervations, that the internal part of the globe conſiſts of the ſtone called granite. It is this which ſhews itſelf as the limit of all the excavations made on the ſurface of our planet, either by natural cauſes or the art of man. The degradations and ſubſequent changes which this rock undergoes

undergoes by the action of water, and which therefore it must have undergone in times past, are so well delineated by Chaptal, that I shall extract his observations in this place.

This fluid, collected in the cavity of the ocean, is carried by the winds to the tops of the most elevated mountains, where it is precipitated in rain, and forms torrents, which return with various degrees of rapidity into the common reservoir.

Such an uninterrupted motion and fall must gradually attenuate, and wear away the hardest rocks, and carry their pulverulent parts to distances more or less considerable. The action of the air, and the varrying temperatures of the atmosphere, facilitate the attenuation and the destruction of these rocks. Heat dries their surface, and renders it more accessible, and more penetrable to the water which succeeds; cold divides them, by freezing the water which has entered into their texture; the air itself affords the carbonic acid, which attacks the lime-stone, and causes it to effloresce; the vital air unites to the iron, and calcines it: insomuch that this concurrence of causes favours the disunion of principles; and consequently the action of water, which clears the surface, carries away the products of decomposition, and makes preparation for a succeeding process of the same nature.

The first effect of the rain is therefore to depress the mountains. But the stones which compose them must resist in proportion to their hardness; and we ought not to be surprised when we observe peaks which have braved the destructive action of time, and still remain to attest the primitive level of the mountains which have disappeared. The primitive rocks, alike inaccessible to the injury of ages as to the animated beings which cover less elevated mountains with their remains, may be considered as the source or origin of rivers or streams. The water which falls on their summits, flows down in torrents by their lateral surfaces. In its course it wears away the soil upon which it incessantly acts. It hollows out a bed of a depth proportioned to the rapidity of its course, the quantity of its waters, and the hardness of the rock over which it flows; at the same time that it carries along with it portions and fragments of such stones as it loosens in its course.

These stones, rolled along by the water, must strike together, and break off their projecting angles; a process that must quickly have afforded those rounded flints which form the pebbles of rivers. These pebbles are found to diminish in size, in proportion to the distance from the mountain which affords them: and it is to this cause that M. Dorthes has referred the disproportionate magnitude of the pebbles which form our ancient worn stones, when compared with those of modern date: for the sea extending itself formerly much more inland, in the direction of the Rhone, the stones which it received from the rivers, and threw back again upon the shores, had not run through so long a space in their beds as those which they at present pass over. Thus it is that the remains of the Alps, carried along by the Rhone, have successively covered the vast interval comprised between the mountains of Dauphiny and Vivarais; and are carried into our seas, which deposit them in small pebbles on the shore.

The pulverulent remains of mountains, or the powder which results from the rounding of these flints, are carried along with greater facility than the flints themselves: they float for a long time in the water, whose transparence they impair: and when these said waters are less agitated, and their course becomes slackened, they are deposited in a fine and light paste, forming beds more or less thick, and of the same nature as that of the rocks to which they owe their origin. These strata

gradually become drier by the agglutination of their principles; they become conſiſtent, acquire hardneſs, and form ſiliceous clays, ſilex, petroſilex, and all the numerous claſs of pebbles which are found diſperſed in ſtrata, or in banks in the antient beds of rivers.

Mr. Pallas has obſerved the tranſition of clay to the ſtate of ſilex in the brook of Sunghir, near Wolodimir. Mr. G. W. Baumer has likewiſe obſerved it in Upper Heſſe.

The mud is much more frequently depoſited in the interſtices left between the rounded flints themſelves, which intervals it fills, and there forms a true cement that becomes hard, and conſtitutes the compound ſtones known by the name of pudding-ſtones and grit-ſtones: for theſe two kinds of ſtones do not appear to me to differ but in the coarſeneſs of the grain which forms them, and the cement which connects them together.

We ſometimes obſerve the granite ſpontaneouſly decompoſed. The texture of the ſtones which form it has been deſtroyed; the principles, or component parts, are diſunited and ſeparated, and they are gradually carried away by the waters. Chaptal obſerved near Mende, towards Caſtelnouvel, the moſt beautiful kaolin on the ſurface of a granite, in a ſtate of decompoſition; and this ſame rock is decompoſed in ſeveral other places. It appeared to him that the feld ſpar was particularly ſubject to be altered the firſt.

Moſt ſiliceous ſtones, formed by the depoſition of fluviatile waters, and hardened by the lapſe of time, are eaſily ſubjected to a ſecond decompoſition. Iron is the principal agent of theſe ſecondary alterations; and its calcination, determined by air or water, produces a diſunion of principles. Nature may be obſerved in this proceſs, by an attentive examination of ſuch alterations as gun flints, variolites, porphyries, jaſpers, and the like, are ſubjected to.

The decompoſition of flints, chalcedonies, agates, and generally all ſtones of this kind which poſſeſs a certain degree of tranſparence, appears to Chaptal to be referable to the volatilization of the water, which forms one of their principles, and is the cauſe of their tranſparency.

Theſe ſtones may be conſidered as commencements of cryſtallization; and when the water is diſſipated, they effervеſce after the manner of certain neutral ſalts. Hence it ariſes that the decompoſition is announced by opacity, a white colour, loſs of conſiſtence and hardneſs; and terminates by forming a very attenuated powder, ſometimes of extreme whiteneſs. It is this decompoſition, more particularly, which forms clays.

There are flints whoſe alterations form effervеſcent marles. Theſe do not appear to Chaptal to be of the nature of primitive rocks: they have the ſame origin as the calcareous ſtones, from which they differ only in conſequence of a very conſiderable proportion of clay. The ſtones which we ſo abundantly find of this nature around us, among calcareous decompoſitions, may be conſidered as of this kind.

Water filtrating through mountains of primitive rock, frequently carries along with it very minutely divided particles of quartz; and proceeds to form, by depoſition, ſtalactites, agates, rock cryſtal, &c.

Theſe quartzoſe ſtalactites, differently coloured, are of a formation conſiderably analogous to that of calcareous alabaſters; and we perceive no other difference between them than that of their conſtituent parts.

Thus far we have exhibited, in a few words, the principal changes, and various modifications, to which the primitive rocks have been ſubjected. We have not obſerved either germination or life: and the metals, ſulphur, and bitumens, have

not

not hitherto preſented themſelves to our obſervation. Their formation appears to be poſterior to the exiſtence of this primitive globe; and the alterations and decompoſitions which now remain to be enquired into, appear to be produced by the claſs of living or organized beings.

On the one hand, we behold the numerous claſs of ſhell animals, which cauſe the ſtony maſs of our globe to increaſe by their remains. The ſpoils of theſe creatures, long agitated and driven about by the waves, and more or leſs altered by colliſion, form thoſe ſtrata and banks of lime-ſtone, in which we very often perceive impreſſions of thoſe ſhells to which they owe their origin.

On the other hand, we obſerve a numerous quantity of vegetables that grow and periſh in the ſea; and theſe plants likewiſe, depoſited and heaped together by the currents, form ſtrata, which are decompoſed, loſe their organization, and leave all the principles of the vegetable confounded with the earthy principle. It is to this ſource that the origin of pit-coal, and ſecondary ſchiſtus, is uſually attributed; and this theory is eſtabliſhed on the exiſtence of the texture of decompoſed vegetables very uſually ſeen in ſchiſti and coal, and likewiſe on the preſence of ſhells and fiſh in moſt of theſe products.

It appears to Chaptal, that the formation of pyrites ought to be attributed to the decompoſition of vegetables: it exiſts in greater or leſs abundance in all ſchiſti and coal. He found a wooden ſhovel buried in the depoſitions of the river De Ceze, converted into jet and pyrites. The decompoſition of animal ſubſtances may be added to this cauſe: and it appears to be a confirmation of theſe ideas, that we find many ſhells paſſed to the ſtate of pyrites.

Not only the marine vegetables form conſiderable ſtrata by their decompoſition; but the remains of thoſe which grow on the ſurface of the globe ought to be conſidered among the cauſes or agents which concur in producing changes upon that ſurface.

We ſhall ſeparately conſider how much is owing to each of theſe cauſes; and ſhall follow the effects of each, as if that cauſe alone were employed in modifying and altering our planet.

1. The calcareous mountains are conſtantly placed upon the ſurface of the primitive mountains; and though a few ſolitary obſervations preſent a contrary order, we ought to conſider this inverſion and derangement as produced by ſhocks which have changed the primitive diſpoſition. It muſt be obſerved alſo, that the diſorder is ſometimes merely apparent; and that ſome naturaliſts of little information have deſcribed calcareous mountains as inclining beneath the granite, becauſe this laſt pierces, as it were, through the envelope, riſes to a greater height, and leaves at its feet, almoſt beneath it, the calcareous remains depoſited at its baſe.

Sometimes even the lime-ſtone fills to a very great depth the crevices or clefts formed in the granite. In Gevaudan, towards Florac, there is a profound cavity in the granite filled with calcareous ſtone. This vein is known to poſſeſs a depth of more than one hundred and fifty toiſes, with a diameter of about two or three.

It likewiſe happens frequently enough, that ſuch waters as are loaded with the remains of the primitive granite heap them together, and form ſecondary granites, which may exiſt above the calcareous ſtone.

Theſe calcareous mountains are decompoſed by the combined action of air and water; and this fluid, which does not poſſeſs the property of holding it in ſolution, ſoon depoſits it in the form of gurhs, alabaſters, ſtalactites, &c. Spars owe their formation

formation to no other cauſe. Their cryſtallization is poſterior to the origin of calcareous mountains.

Waters wear down and carry away calcareous mountains with greater eaſe than the primitive mountains: their remains being very light, are rolled along, and more or leſs worn. The fragments of theſe rocks are ſometimes connected by a gluten or cement of the ſame nature; from which proceſs calcareous grit and breccias ariſe. Theſe calcareous remains formerly depoſited themſelves upon the quartzoſe ſand; and the union of primitive matter and ſecondary products gives riſe to a rock of a mixed nature, which is common in our province.

2. The mountains of ſecondary ſchiſtus frequently exhibit to us a pure mixture of earthy principles, without the ſmalleſt veſtige of bitumen. Theſe rocks afford, by analyſis, ſilex, clay, magneſia, lime in the ſtate of carbonate, or mild, and iron; principles which are more or leſs united, and conſequently acceſſible in various degrees to the action of ſuch agents as deſtroy the rocks hitherto treated of.

Theſe ſame principles, when diſunited, and carried away by waters, give riſe to a great part of the ſtones compriſed in the magneſian genus. The ſame elements worn down by the waters, and depoſited under circumſtances proper to facilitate cryſtallization, form the ſchorls, tourmaline, garnets, &c.

Chaptal does not pretend by this to exclude and abſolutely reject the ſyſtem of ſuch naturaliſts as attribute the formation of magneſian ſtones to the decompoſition of the primitive rocks. But he thinks that this formation cannot be objected to for ſeveral of them, more eſpecially ſuch as contain magneſia in the greateſt abundance.

It frequently happens that the ſecondary ſchiſti are interſperſed with pyrites; and, in this caſe, the ſimple contact of air and water facilitates their decompoſition. Sulphuric acid is thus formed, which combines with the various conſtituent principles of the ſtone; whence reſult the ſulphates or vitriols of iron, of magneſia, of clay, and of lime, which efflores̈ce at the ſurface, and remain confounded together. Schiſti of this nature are wrought in moſt places where alum works have been eſtabliſhed; and the moſt laborious part of this undertaking conſiſts in ſeparating the ſulphates of iron, of lime, and of magneſia from each other, which are mixed together. Sometimes the magneſia is ſo abundant that its ſulphate predominates: Chaptal obſerved mountains of ſchiſtus of this nature. The ſulphate of lime being very ſparingly ſoluble in water, is carried away by that liquid, and depoſited to form gypſum; while the other more ſoluble ſalts remaining ſuſpended, form vitriolic mineral waters.

The pyritous ſchiſti are frequently impregnated with bitumen, and the proportions conſtitute the various qualities of pit-coal.

It appears to Chaptal, that we may lay it down as an inconteſtable principle, that the pyrites is abundant in proportion as the bituminous principle is more ſcarce. Hence it ariſes, that coals of a bad quality are the moſt ſulphureous, and deſtroy metallic veſſels by converting them into pyrites. The focus of volcanos appears to be formed by a ſchiſtus of this nature; and in the analyſes of the ſtony matters which are ejected, we find the ſame principles as thoſe which conſtitute this ſchiſtus. We ought not therefore to be much ſurpriſed at finding ſchorls among volcanic products; and ſtill leſs at obſerving that ſubterranean fires throw ſulphuric ſalts, ſulphur, and other analogous products out of the entrails of the earth.

3. The

3. The remains of terreſtrial vegetables exhibit a mixture of primitive earths more or leſs coloured by iron: we may therefore conſider theſe as a matrix in which the ſeeds of all ſtony combinations are diſperſed. The earthy principles aſſort themſelves according to the laws of their affinities; and form cryſtals of ſpar, of plaſter, and even the rock cryſtals, according to all appearance: for we find ochreous earths in which theſe cryſtals are abundantly diſperſed; we ſee them formed almoſt under our eyes. We may frequently obſerve indurated ochres full of theſe cryſtals terminating in two pyramids.

The ochreous earths appear to deſerve the greateſt attention of naturaliſts. They conſtitute one of the moſt fertile means of action which nature employs; and it is even in earths nearly ſimilar to theſe that ſhe elaborates the diamond, in the kingdoms of Golconda and Viſapour. If it were allowable, ſays our author, to indulge in a fiction purely poetical, we might affirm that the element of fire, ſo far from being loſt by the diſperſion of the combuſtible principles of vegetables, becomes purified to form this precious ſtone ſo eminently combuſtible; that nature has been deſirous of proving that the terms deſtruction and death are relative only to the imperfection of our ſenſes; and that ſhe is never more fruitful than when we ſuppoſe her to be at the moment of extinction.

The ſpoils of animals, which live on the ſurface of the globe, are entitled to ſome conſideration among the number of cauſes which we aſſign to explain the various changes our planet is ſubjected to. We find bones in a ſtate of conſiderable preſervation in certain places; we can even frequently enough diſtinguiſh the ſpecies of the animals to which they have belonged. From indications of this ſort it is that ſome writers have endeavoured to explain the diſappearance of certain ſpecies; and to draw concluſions from thence, either that our planet is perceptibly cooled, or that a ſenſible change has taken place in the poſition of the axis of the earth. The phoſphoric ſalts and phoſphorus, which have been found, in our time, in combination with lead, iron, &c. prove that, in proportion as the principles are diſengaged by animal decompoſition, they combine with other bodies, and form the nitrous acid, the alkalis, and in general all the numerous kinds of nitrous ſalts.

MOUNTAIN BLUE. An ore of copper of a blue colour, moſt frequently of a looſe pulverulent form, but ſometimes indurated and even cryſtallized, but then it is mixed with quartz. One hundred parts of it, according to Kirwan, contain about ſixty-nine of copper, twenty-nine of fixed air, and two of water. Morveau, in the Memoirs of Dijon for 1782, quoted by this author, ſhews that the calces of copper are determined rather to a blue than a green colour, by a greater proportion of phlogiſton, viz. the metal is nearer the metallic ſtate.

Theſe ores are analyſed in the moiſt way by ſolution in acids, and precipitation by the mineral aërated alkali, if they be pure, or by the Pruſſian alkali, if they contain earths. One hundred and ninety-four grains of the precipitate formed by the mineral alkali, are equivalent to 100 of copper in its metallic ſtate: ſo alſo are 350 grains of the precipitate formed by the Pruſſian alkali, as Mr. Bergman has determined: copper alſo may be precipitated in its metallic ſtate by means of iron, though it is not eaſy to get it pure, if the nitrous acid be the ſolvent.

In the dry way, after torrefaction, they may be eſſayed by melting them with one-half or three-fourths of their weight of borax, and one-fourth of their weight of pitch. Some loſs always attends the black flux.

MOUNTAIN GREEN is generally found in a looſe and friable ſtate, rarely cryſtallized and indurated, often mixed with calcareous earth and iron, and

ſome arſenic. One hundred parts of the pureſt contain 72 of copper, 22 of aërial acid, and 6 of water. See alſo MALACHITE.

MUCILAGE. A general term uſed to denote a ſubſtance, ſoluble in water, whether hot or cold, with which it forms a tranſparent adheſive or gluey maſs. When obtained from vegetables, it is diſtinguiſhed by the name of GUM; when from animal ſubſtances, it is called GLUE, or JELLY. Conſult the the articles.

When animal mucilage has been extracted without long boiling, it then poſſeſſes moſt of the characters of gum. It is thought that the difference between gum and glue conſiſts in the mixture of ſerum in the latter. It is probable however, that the principles which render glue more diſpoſed to the putrid fermentation inſtead of the acidity acquired by gums, are not merely mixed, but intimately combined.

MUFFLE. A ſmall earthen oven made and ſold by the crucible manufacturers. It is to be fixed in a furnace, and is uſeful for cupellation, and other proceſſes which demand acceſs of air.

MUMIA. This was found in the ſea on the coaſts of Finland, in the year 1736; it is perfectly white, and of the conſiſtence of tallow, but more brittle, though as greaſy. Its ſpecific gravity is 0,770, whereas that of tallow is 0,969; it burns with a blue flame, and a ſmell of greaſe, leaving a black viſcid matter, which is more difficultly conſumed: it is ſoluble in ſpirit of wine only when tartariſed, and even then leaves an inſoluble reſiduum, but expreſſed oils diſſolve it when boiling. It is alſo found in ſome rocky parts of Perſia, but ſeems mixed with petrol, and is there called Schebennaad, Tſienpen, Kodreti *. Mr. Herman, a phyſician of Straſburgh, mentions a ſpring in the neighbourhood of that city, which contains a ſubſtance of this ſort diffuſed through it, which ſeparates on ebullition, and may then be collected. Kirwan.

MURIATIC ACID. See ACID MARINE.

MUSCOVY GLASS conſiſts of broad, elaſtic, flexible, tranſparent leaves, and differs externally from mica, only in being ſofter, and more ſoapy to the touch. It is capable of being ſplit into laminæ of the two or three hundredth part of an inch thick, and the plates naturally exhibit a ſtrong electric ſtate, and ſparks, when torn aſunder in the dark, even though previous friction be carefully avoided. Few ſpecimens are as tranſparent as glaſs.

MUSK. See CIVET.

MUST. The juice of the grape previous to the commencement of fermentation. The word is likewiſe occaſionally uſed to denote other ſaccharine juices in the ſame ſtate.

MYRRH. A gum reſin, brought from the Eaſt Indies, and likewiſe from Alexandria, Smyrna, and Aleppo. It is hard, dry, gloſſy, of various colours, yelloviſh, reddiſh, brown, yelloviſh-brown, reddiſh-brown, blackiſh, intermixed with whitiſh ſpecks or tears, tranſparent like agate, or opake like pitch, of a peculiar ſtrong ſmell, and a bitter ſomewhat biting taſte. The beſt is that which is of a reddiſh-brown colour, not verging too much to yelloviſh or blackiſh; uniform on the outſide, internally ſpecked or ſtreaked with white, clear and bright, ſomewhat unctuous to the touch, but not tenacious ſo as to ſtick to the fingers.

This gummy reſin is liable to great abuſes: the larger maſſes in particular are frequently no other than ſome artificial compoſition, ſkilfully incruſtated on

* Mem. Sued. 87. 2 Lin. von Gmel. 389. Gerh. Beytr. 211.

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the outside with a solution of myrrh. Some report that bdellium is nearly allied to myrrh, and not easily to be distinguished from it; the differences however are sufficiently obvious, bdellium being darker coloured and less transparent than good myrrh, internally soft and tenacious (which myrrh never is), yielding a quite different smell, and wanting its bitterness.

From sixteen ounces of myrrh Neumann obtained, by means of water, twelve and a half of gummy extract; and from the residuum by rectified spirit, one and a half of resin. On treating the same quantity first with spirit, and afterwards with water, he obtained five ounces of resinous and eight ounces six drams of gummy extract. The indissoluble matter amounted in both operations to two ounces, or one eighth of the myrrh.

In distillation with water, an essential oil arises, to the quantity of three drams from a pound. This oil smells and tastes extremely strong of the myrrh, and contains all that part in which the peculiar qualities of the juice reside: it differs remarkably from that of the other gummy resins, in not being hot or pungent, in being so ponderous as to sink in water, and in not being in the least elevated by spirit of wine; highly rectified spirit, distilled from myrrh, receiving no sensible impregnation either in smell or taste.

It is further observable, that whether myrrh be digested in water or in spirit, the whole of its smell and taste is taken up by the menstruum applied first: the extracts made by water after spirit has performed its office, as well as that by spirit after water, are inodorous and insipid. Both the tincture and the extract made by pure spirit at first, contain all the active parts of the myrrh. The watery infusion or decoction, if made in such a manner as to prevent evaporation, does the same; but on exhaling it to the consistence of an extract, all the flavour of the myrrh is lost, and nothing but its bitterness remains: no one can distinguish in the watery extract any thing of the specific characters of the myrrh. From these experiments we learn in what manner this juice is to be treated to the best advantage, and in what preparations its virtues are preserved or lost.

On inclosing some powdered myrrh in the white of a hard boiled egg, and setting it in a moist cellar, the liquor into which the egg is by degrees resolved, extracts nearly all the smell and taste of the myrrh. This liquor, commonly called Oleum myrrhæ per deliquium, is precipitated or coagulated by spirit of wine; and the unctuous coagulum, separated from the spirit, dissolves again in pure water. This process has been applied likewise to mastich and other pure resins; but from those the white of eggs extracts nothing.

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NAPHTHA. A fine thin fragrant colourless oil, which issues out of white, yellow, or black clays in Persia and Media, is known by this name. It burns with a bluish yellow flame, and is as inflammable as æther, and, like it, extracts

gold from aqua regia. It is not decompoſed by diſtillation; and yet, if long expoſed to the air, it changes colour, thickens, and degenerates into petrol. Its ſmell is very different from that of vegetable oils; it diſſolves reſins and balſams; but not gum reſins, nor elaſtic gum. It diſſolves the eſſential oils of thyme and lavender; but is inſoluble in ſpirit of wine and æther. Its ſpecific gravity is 0,708.

NARD INDIAN, or SPIKE-NARD, conſiſts of a number of ſlender brittle filaments, ſuppoſed by ſome to be the root, by others, the pedicle of the leaves of a plant of the graſs or ruſh kind; but which are properly the head of a root, for Pomet mentions and figures a ſpecimen, which had great part of the root adhering.

Spikenard has a very ſtrong, not agreeable ſmell and taſte, ſcarce to be concealed or overpowered by a large admixture of other ſubſtances. In the Theriaca Cœleſtis, a compoſition of many drugs of ſtrong ſmells and taſtes, ſpikenard enters but in ſmall quantity, and yet it prevails over all the others. It contains, however, only a ſmall proportion of eſſential oil: on diſtilling an ounce, there was only an appearance of ſome oily particles on the ſurface of the water. Rectified ſpirit brings over nothing: the ſpirituous extract poſſeſſes both the ſmell and taſte of the ſpikenard, in a much greater degree than the watery. An ounce yielded a dram of ſpirituous, and afterwards forty-ſix grains of watery extract; water applied at firſt extracted from the ſame quantity four ſcruples, and ſpirit afterwards twenty-five grains: the indiſſoluble reſiduum weighed in both caſes ſix drams ten grains.

NATRON, or NATRUM. A native alkaline ſalt, of the nature of the mineral, or marine alkali, which is found cryſtallized in Egypt, and other hot countries, in ſands which ſurround lakes of ſalt water. There is no doubt but the common ſalt is decompoſed, and loſes its acid; but whether by the action of the air, of the mere heat of the ſun, or, which is more probable, the effect of its light, has not been determined. In the new nomenclature of our College of Phyſicians, the mineral alkali is called natron.

NAUTILITES. A calcareous ſtone, or petrifaction of the nautilus. Some writers, who have called theſe ſerpent-ſtones, and ſuppoſed them to have been produced by a petrifaction of that creature, have expreſſed their ſurpriſe that the head is always wanting.

NEPHRITIC STONE. See JADE.

NEPHRITIC WOOD. This wood gives a blue colour to ſpirit of wine, or to water. This colour is changed to a yellow by acids, and afterwards reſtored to a blue by alkalis. Dr. Lewis obſerves, that it is the only woody matter which gives a blue tincture; and that this is the only vegetable blue which is thus deſtructible by acids.

NEUTRAL SALTS. This term is applied to all ſalts which contain an acid ſaturated with an alkali, an earth, or a metal. Bergmann confined it to ſalts containing alkali; and he called the earthy and metallic ſalts, middle ſalts. It is moſt uſual to call the alkaline ſalts with an acid neutral, and to diſtinguiſh the others by the reſpective appellations, earthy and metallic.

NICKEL is a reddiſh white metallic ſubſtance, of great hardneſs, and of an uniform texture; very difficult to be purified, and always magnetical, whence it has been ſuppoſed to contain iron in its pureſt ſtate. It is malleable, and is ſcarcely more fuſible than pure iron. Its calces are of a green colour.

This metallic ſubſtance has not been applied to any uſe; and the chief attention of thoſe chemiſts who have examined it, has been directed to obtain it in a

ſtate of purity; which, however, has not yet been accompliſhed. It is found either native or calciform; but moſt commonly mineralized in combination with arſenic, ſulphur, cobalt, and iron in the ore, called kupfer nickel, or falſe copper. This is of a reddiſh yellow, or coppery colour; of a texture either uniform, granular, or ſcaly; bright in its fracture, and almoſt always covered with a green efflorescence of calx. Moſt of the ſulphur and arſenic may be driven off by long continued roaſting, and the occaſional addition of charcoal, which prevents the arſenic from being rendered more fixed by calcination; and the green calx which remains may be fuſed by the ſtrongeſt heat of a ſmith's forge, together with two or three times its weight of black flux. The regulus thus obtained is of a reddiſh white colour, and brittle; but is very far from being pure. Repeated calcinations for many hours, and reductions, ſcarcely deprive the regulus of iron; and it is ſtill highly magnetic when purified to ſuch a degree as to poſſeſs conſiderable malleability. Combination with ſulphur, with liver of ſulphur, detonation with nitre, and ſolution in the volatile alkali and vitriolic acid, did not deprive it of its magnetiſm.

When the regulus*, obtained by ſcorification and reduction, was combined with ſulphur, and reduced again after the diſſipation of the ſulphur by ſtrong heat, and the addition of charcoal, to promote the volatility of the arſenical contents, and this proceſs was three times repeated; the reduced metal was ſo infuſible, as not to run into a maſs by the ſtrongeſt heat of a ſmith's forge, continued for three quarters of an hour. Its colour was then whitiſh, mixed with a glittering kind of red; it was ſtrongly magnetical; of a ſpecific gravity of 8,66; and a globule of one line in diameter was extended by the hammer into a plate of upwards of three lines in diameter: ſo that it is, properly ſpeaking, an entire metal, and not a ſemi-metal. It afforded a blue ſolution with the volatile alkali; and in nitrous acid its ſolution was of a full green.

Concentrated vitriolic acid acts upon the regulus of nickel, and corrodes it. The reſidue, after diſtillation of the acid, is a greyiſh powder; part of which is in the ſaline ſtate, and affords green cryſtals by ſolution in water and evaporation.

The nitrous ſolution of this metal affords ſaline cryſtals. Alkalis precipitate it, and rediſſolve the precipitate. Nitre detonates with nickel in the dry way. Sulphur readily combines with it by fuſion, as does likewiſe arſenic; and both adhere very pertinaciouſly to it, as has been already ſhewn.

Nickel has been thought to be a modification of iron. This concluſion is grounded chiefly on its magnetiſm, and the conſideration of the very remarkable and different properties iron is known to be capable of aſſuming in its ſeveral ſtates. Others have ſuppoſed it to be an alloy of copper with various metallic admixtures. The blue colour it affords with volatile alkali, is the chief circumſtance which gave riſe to this opinion. But it has been very properly obſerved †, that many of the known metals would ſcarcely have endured more ſevere trials than this ſubſtance has undergone, without ſhewing indications, at leaſt as ſtrong, againſt the ſuppoſition of their being diſtinct bodies, as any afforded by nickel; and conſequently, that ſo long as no one is able to produce this metal from pure iron or copper, and to explain in an intelligible way the proceſs by which it can be generated, we muſt continue to regard it as a peculiar ſubſtance, poſſeſſing diſtinct properties. The general opinions of the chemiſts concur in admitting the force of this reaſoning.

* Bergman on Nickel, in vol. ii. of his Eſſays.

† Bergman, ii. 264.

NIHIL ALBUM, a name given to the white calx of zinc, driven up during the combuſtion of that ſemi-metal, or the treatment of ores which contain it.

NITRE. Nitre with an alkaline baſis is found ready formed in the Eaſt Indies, in Spain, in the kingdom of Naples, and elſewhere, in conſiderable quantities, but more abundantly in combination with a calcareous baſis. For the greater part of the nitre made uſe of is produced by a combination of circumſtances which tend to compoſe and condenſe the acid of nitre. Nitrous acid appears to be produced in all ſituations where animal matters are completely decompoſed, with acceſs of air, and of proper ſubſtances with which it can readily combine. Grounds frequently trodden by cattle and impregnated with their excrements, or the walls of inhabited places where putrid animal vapours abound, ſuch as ſlaughter-houſes, drains, or the like, afford nitre by long expoſure to the air. Artificial nitre beds are made by an attention to the circumſtances in which this ſalt is produced by nature. Dry ditches are dug, and covered with ſheds, open at the ſides, to keep off the rain: theſe are filled with animal ſubſtances—ſuch as dung, or other excrements, with the remains of vegetables, and old mortar, or other looſe calcareous earth; this ſubſtance being found to be the beſt and moſt convenient receptacle for the acid to combine with. Occaſional watering, and turning up from time to time, are neceſſary to accelerate the proceſs, and increaſe the ſurfaces to which the air may apply. After a ſucceſſion of many months, more or leſs, according to the management of the operation, in which the action of a regular current of freſh air is of the greateſt importance, nitre is found in the maſs. If the beds contained much vegetable matter, a conſiderable portion of the nitrous ſalt will be common ſaltpetre; but, if otherwiſe, the acid will, for the moſt part, be combined with the calcareous earth.

To extract the ſaltpetre from the maſs of earthy matter, a number of large caſks are prepared, with a cock at the bottom of each, and a quantity of ſtraw within, to prevent its being ſtopped up. In theſe the matter is put, together with wood-aſhes, either ſtrewed at top, or added during the filling. Boiling water is then poured on, and ſuffered to ſtand for ſome time; after which it is drawn off, and other water added in the ſame manner, as long as any ſaline matter can be thus extracted. The weak brine is heated and paſſed through other tubs, until it becomes of conſiderable ſtrength. It is then carried to the boilers, and contains nitre and other ſalts; the chief of which is common culinary ſalt, or the marine acid united to the mineral alkali, or ſometimes to magneſia. It is the property of nitre to be much more ſoluble in hot than cold water; but common ſalt is ſoluble very nearly as much in cold as in hot water. Whenever, therefore, the evaporation is carried by boiling to a certain point, much of the common ſalt will fall to the bottom, for want of water to hold it in ſolution, though the nitre will remain ſuſpended by virtue of the heat. The common ſalt thus ſeparated is taken out with a perforated ladle, and a ſmall quantity of the fluid is cooled, from time to time, that its concentration may be known by the nitre which cryſtallizes in it. When the fluid is ſufficiently evaporated, it is taken out, and cooled, and great part of the nitre ſeparates in cryſtals; while the remaining common ſalt continues diſſolved, becauſe equally ſoluble in cold as in hot water. Subſequent evaporation of the reſidue will ſeparate more nitre in the ſame manner.

This nitre, which is called nitre of the firſt boiling, contains ſome common ſalt; from which it may be purified by ſolution in a ſmall quantity of water, and ſubſequent evaporation: for the cryſtals thus obtained are much leſs contaminated with

with common ſalt than before; becauſe the proportion of water is ſo much larger, with reſpect to the ſmall quantity contained by the nitre, that very little of it will cryſtallize. For nice purpoſes, the ſolution and cryſtallization of nitre are repeated four times. The cryſtals of nitre are uſually of the form of ſix-ſided flattened priſms, with dihedral ſummits. Its taſte is penetrating; but the cold produced by placing the ſalt to diſſolve in the mouth, is ſuch as to predominate over the real taſte at firſt. Seven parts of water diſſolve one of nitre, at the temperature of ſixty degrees; but boiling water diſſolves its own weight.

If nitre be expoſed to a ſtrong heat, it melts, and becomes red hot; and the volatile product is found to conſiſt of fuming nitrous acid, a large quantity of vital air, and ſome phlogiſticated air; the alkali remaining behind, ſomewhat altered by a portion of the earth of the retort which it has diſſolved. Moſt other nitrous ſalts give out vital air by the ſame treatment. The extreme difficulty of aſcertaining the weights of aerial products, and of the fixed reſidues, renders it an embarraſſing taſk to ſhew by real experiment what happens in this operation among the principles of nitre. See ACID NITROUS.

When a combuſtible body and nitre are brought into contact, either of them being previouſly heated red hot, the body is burned with great rapidity, no doubt by the vital air which the nitre affords by the heat; for the experiment ſucceeds in vacuo, and alſo when the bodies are ſurrounded by any aerial fluid incapable of maintaining combuſtion. This rapid combuſtion, effected by means of nitre, is called deflagration, when it is performed by a ſucceſſive burning of the parts of the body; or detonation, when the combuſtion of the whole is performed in ſo ſhort a time as to appear inſtantaneous. In this experiment, it is remarkable that the combuſtion is maintained by vital air which is not in the elaſtic ſtate, but fixed in the nitre. Whence it ſhould follow, that either the vital air, or the combuſtible body, even in the fixed ſtate, has a great capacity for heat, of which it muſt contain a large quantity, on the hypotheſis of heat being matter. Or, if heat be a mere commotion, it will follow, that though the quantity of agitation produced by the ſudden coalition of particles, in the act of converting an elaſtic fluid into a denſe body, be ſuch as to produce a great effect in increaſing the temperature; yet the quantity is ſtill ſo conſiderable, when vital air and combuſtible matter unite even in their denſe ſtate, as to cauſe the moſt intenſe degree of ignition. See GUNPOWDER.

NITRE (ALKALISED). This is the fixed alkali which remains after the nitrous acid has been deſtroyed by its detonation with any inflammable matter. This alkali is generally called fixed nitre.

NITRE (AMMONIACAL). The neutral ſalt reſulting from the combination of the nitrous acid, to the point of ſaturation, with volatile alkali, has been thus named. See AMMONIACAL NITROUS SALT.

NITRE (CALCAREOUS), OR NITRE WITH EARTHY BASIS. Calcareous nitre is a neutral ſalt compounded of the nitrous acid combined to ſaturation with a calcareous earth. It is generally called nitre with an earthy baſis, becauſe the ſalts formed by the nitrous acid with the other earths have been leſs attended to.

Nitrous acid diſſolves with great activity all calcareous earths and ſtones, calcined or uncalcined. It diſſolves a large quantity of them, and leaves no reſiduum when they are pure. By this combination is formed a neutral ſalt very deliqueſcent. This ſalt is not ſuſceptible of a true cryſtallization. It has a poignant, acrid, and bitter taſte. If it be evaporated to dryneſs, it becomes ſolid,

ſolid, and ſeems to be an earthy matter, which does not detonate, or at leaſt very weakly, with inflammable matters.

The adheſion of the acid to its baſis is ſo weak, that if the ſalt be diſtilled in a retort, an aciduous phlegm will firſt paſs over; and when the fire is increaſed, all the acid will follow, excepting a ſmall portion which adheres more ſtrongly, but which may be at laſt expelled by calcination in an open fire.

A great quantity of nitre with earthy baſis is found ready formed in nitrous earths and ſtones. Nitre is moſt frequently produced in that form. This nitre may be decompoſed by a fixed alkali, which unites with its acid and precipitates the earth, in the proceſs for making ſaltpetre. The mother-waters obtained in theſe operations contain ſtill a large quantity of this nitre with earthy baſis. See the word NITRE in the preceding article.

NITRE (CUBIC OR QUADRANGULAR). When nitrous acid is ſaturated with mineral alkali, a neutral ſalt is formed, ſuſceptible of cryſtallization and of detonation, and conſequently is a kind of nitre. This ſalt has all the eſſential properties of nitre with baſis of fixed vegetable alkali; but the marine alkali, which is its baſis, changes the form of its cryſtals, which are not channelled priſms, like thoſe of ordinary nitre, but are cubes, or ſometimes parallelopipedons, with rhomboidal faces. From theſe forms the ſalt has been called quadrangular nitre.

We may make quadrangular nitre by combining directly the nitrous acid to the point of ſaturation with the cryſtals of ſoda, or by precipitating with this alkali the ſolutions of earths and metals made by nitrous acid, or by precipitating with common ſalt the metallic ſolutions in nitrous acid, which are ſuſceptible of this precipitation; or, laſtly, by decompoſing common ſalt by pure nitrous acid in the operation for making the diſtilled aqua regia. In all theſe caſes the nitrous acid is evidently combined with marine alkali, and forms cubic nitre. This ſalt is not uſed in medicine, chemiſtry, or the arts, as it is rather inferior than preferable to ordinary nitre.

NITRE FIXED, OR ALKALISED BY COALS. To make this extemporaneous alkali, the proper quantity of nitre is to be put into a crucible, which ought to be ſo large that the nitre ſhall take up but a ſmall ſpace in it. This crucible is to be placed in a well kindled fire; and when the nitre is melted and red hot, a ſmall ſpoonful (about a dram or half a dram) of charcoal groſsly powdered is to be projected upon it. Inſtantly a vivid inflammation happens, which continues till all the charcoal is entirely conſumed. When this inflammation or detonation ceaſes, another quantity of charcoal like the former is projected upon it, and is left to be conſumed; and thus charcoal is continually to be projected till no more detonation is cauſed by it.

The matter contained in the crucible, which at firſt is very fluid, becomes afterwards thick and almoſt ſolid, becauſe it is then fixed alkali, which is much leſs fuſible than nitre. The fire muſt be increaſed ſufficiently to make this alkali melt. During this fuſion, ſome ſmall detonations happen from time to time, which are occaſioned by a portion of nitre, which the large quantity of alkali, and the want of fluidity towards the end of the operation, had preſerved from the contact of the coals. When the matter is in good fuſion, and no detonation happens upon projecting ſmall bits of coals, we may then know that the nitre is alkaliſed, and that the operation is finiſhed.

NITRE FIXED BY METALS. All the metallic ſubſtances which are ſuſceptible of decompoſition being treated in the fire with nitre, alkaliſe it, and make

make it detonate more or leſs ſenſibly. The moſt inflammable of theſe ſubſtances, as zinc and iron, make with this ſalt ſo luminous and ſo brilliant a detonation, that they are advantageouſly employed for that purpoſe in fireworks. Other combuſtible matters are leſs effectual, but their inflammation with nitre is ſufficiently ſtrong to produce all the eſſential effects of the detonation of nitre: ſo that after this inflammation, the acid of the ſalt is decompoſed by the combuſtion of theſe metals, and its alkali only remains mixed with the earth of the calcined metals.

After the detonation of nitre with metals, its alkali may be eaſily obtained alone, and ſeparated from the metallic earths, by lixiviating the remainder with water. By filtrating and evaporating this water, this kind of fixed nitre may be obtained in a dry ſtate. It is eſſentially the ſame as nitre alkaliſed by any other inflammable matter, but it is in the cauſtic ſtate.

NITRE FIXED, OR ALKALISED BY TARTAR. This alkali is made by mixing together equal parts of nitre and tartar, which ought to be only groſſly powdered. This mixture is to be put into an open veſſel of unvarniſhed earthen ware, or of iron. It is to be placed under a chimney, and it is to be kindled with a lighted coal. It kindles around the charcoal, and deflagrates at firſt weakly: but as the matter firſt inflamed kindles the reſt, the detonation increaſes, a thick fume riſes, and the whole mixture is inflamed. The red and burning matter melts, boils, and flows over the veſſel, if this be not ſufficiently large: then the detonation gradually diminiſhes, and at laſt ceaſes. The reſiduum conſiſts of the alkalis of nitre and of tartar mixed together.

This alkali, as well as the nitre fixed by coals, are each of them very pure and good. They are, however, ſubject to contain a conſiderable quantity of nitre undecompoſed, and of inflammable matter not burnt, particularly when a ſmall quantity only is prepared at once; but the maſs may be completely alkaliſed by a proper calcination, and by treating it like other fixed alkalis. See ALKALI (FIXED VEGETABLE).

Nitre fixed by tartar is alſo called white flux, becauſe the moſt frequent uſe of this alkali is to facilitate the fuſion of ores and metallic matters in eſſays and ſimilar operations, for which purpoſes it needs not be perfectly pure. See FLUX (WHITE) and DETONATION OF NITRE.

NITRES (METALLIC), OR NITRES WITH METALLIC BASES. See the METALS.

NITRO-MURIATIC ACID. The compound acid formed by uniting the nitrous and marine acids. It is commonly known by the name of AQUA REGIA, which ſee.

NITROUS ACID. See ACID NITROUS.

NITROUS AIR. See AIR NITROUS.

NOBLE METALS. This abſurd name has been beſtowed on the perfect metals, gold, ſilver, and platina.

NOMENCLATURE. Whenever a new ſubſtance or thing comes under our notice we give it a name, and in this denomination we ſeldom fail to recur to ſome of the properties or habitudes of the thing. If this were invariably done, and the knowledge of the property or habitude alluded to were perfect, it is evident that a knowledge of the derivation of names would, in almoſt every inſtance, convey a large portion of knowledge. On the other hand it is no leſs evident, that names founded upon miſtaken inferences reſpecting the properties of things, will be received and uſed as the characteriſtic marks of thoſe properties, and will greatly

greatly tend to diſtribute and perpetuate error. Hence the advantages of an accurate nomenclature, eſpecially in the ſcience of matter of fact, which chemiſtry may be peculiarly termed. Every writer has been more or leſs ſenſible of the advantages of accurate denomination. Many have attempted to improve the nomenclature of chemiſtry, as opportunity offered. Old names have been rejected, and new ones adopted from time to time, and that to ſuch an extent, that the common terms of philoſophical chemiſtry had become conſiderably remote from thoſe uſed in pharmacy, till the late reformation of the Diſpenſatory of the College of Phyſicians. The nomenclature which has moſt extenſively prevailed among the modern chemical writers of this country, is that of Bergmann. He denominates the five ſimple earths by the names of calcareous, argillaceous, ſiliceous, ponderous, and magneſian earths; the alkalis are, fixed vegetable, fixed mineral, and volatile; for the acids, he uſes the old denominations, either adjectively, as the nitrous acid, or ſubſtantively, as the acid of nitre. The metallic ſubſtances are called by their own names, and ſaid to be calcined, or converted into calx, by any of the proceſſes of combuſtion. In the denomination of compound ſubſtances, into which an acid enters, he converts the name of the acid into an adjective, and applies it to the earthy, alkaline, or metallic baſis; as in the examples, vitriolated vegetable alkali, nitrated ſilver, or muriated ponderous earth. He deſignates the aerial ſubſtances by the name of gas.

The French chemiſts who have rejected the phlogiſton, and have ſhewn the moſt active zeal in propagating the ſyſtematical doctrine, of which the abſorption and extrication of vital air, and the compoſition and decompoſition of water, are the leading features, have been particularly attentive to the reformation of chemical nomenclature. Meſſrs. De Morveau, Lavoiſier, Berthollet, and De Fourcroy, publiſhed a method of chemical nomenclature at Paris, in the year 1787; and ſince that time, moſt of the valuable treatiſes publiſhed in France, or tranſlated into the French language, have followed that enunciation. It appears therefore to be neceſſary, that every chemiſt who propoſes to make conſiderable advances in the ſcience, muſt acquire a knowledge of this chemical language, whether he may be diſpoſed to admit the principles on which it is founded, or the contrary.

In the plan theſe chemiſts propoſed, ſimple bodies, viz. ſuch as had not hitherto been decompoſed, were entitled in the firſt place to their attention, becauſe the denomination of ſubſtances reduced to their elements by accurate analyſis would be naturally determined by uniting the ſigns of thoſe elements.

Theſe undecompoſed ſubſtances are divided by them into five claſſes.

The firſt claſs comprehends thoſe principles which, though they do not exhibit any remarkable analogy to each other, have nevertheleſs this common property, that they appear to approach in an eminent degree to that ſtate of ſimplicity, which enables them to reſiſt the methods of chemical analyſis, at the ſame time that it renders them highly active in combinations.

In the ſecond claſs they place all thoſe ſubſtances which are capable of being converted into acids. The phlogiſtian philoſophers maintain that this converſion is produced by the expulſion of phlogiſton, at the ſame time that the facts compel them to admit the contemporaneous abſorption of vital air. The antiphlogiſtian philoſophers admit only the ſimple fact of the abſorption and combination of vital air, or its baſis, with the acidifiable ſubſtance, which they conſider as undecompoſable or ſimple. Hence they call it the acidifiable baſis, or radical principle of the acid. See the reſpective Acids.

The

The third claſs comprehends all thoſe ſubſtances which can be exhibited under the metallic form. The regulus, or metal itſelf, is the ſimple ſubſtance. See METALS.

The fourth claſs comprehends the earths, and

The fifth the alkalis.

At the end of theſe five claſſes, they point out, in an appendix, certain ſubſtances of a more compounded nature, which combine in the manner of more ſimple bodies, without undergoing any obſervable decompoſition. It appeared neceſſary that theſe bodies ſhould enter into the table of methodical nomenclature, to complete the ſyſtem.

The ſubſtances of the firſt claſs are five in number, viz. light, the matter of heat, the air formerly called dephlogiſticated air, and afterwards vital air, inflammable air, and phlogiſticated air. The latter is placed in their table in the claſs of acidifiable baſes, becauſe it is in fact the baſis of the nitrous acid. Chaptal calls it nitrogene, for this reaſon; but Morveau, in his Memoir, which I chiefly follow in the preſent account, thinks it requiſite from ſeveral of its properties to treat of it in this firſt claſs.

Light and heat in certain circumſtances appear to produce the ſame effects; but our knowledge not being ſufficiently advanced to affirm either their identity or their difference, theſe nomenclators choſe to preſerve the diſtinctive appellation to each; excepting that, as they admit of a material principle which is the cauſe of the ſenſation denoted by the word *heat*, they thought fit to give it the name *caloric*. Whenever therefore the word *caloric* is uſed, it denotes the ſame thing as the words *matter of heat* imply in the writings of modern philoſophers.

The terms *vital air* were rejected, becauſe the property of maintaining light, and the exiſtence of the aëriform ſtate, do not accurately deſignate the ſubſtance which enters into combination after giving out heat and light. For ſince heat and light are conſidered by theſe philoſophers to be material ſubſtances, the vital air will according to them conſiſt of light, heat, and another ſubſtance which they call oxygene, a word which denotes the generator of acid.

For ſimilar reaſons, they have rejected the terms *inflammable air*, and called the ſubſtance formerly ſo denominated by the name of *hydrogene*, when diſengaged from light and heat. This denomination is grounded on its property of compoſing water when united with oxygene.

The denomination of *phlogiſticated air* has been received by chemiſts in general with diſlike, on account of its expreſſing too ſtrongly a theory at leaſt doubtful. Many have rejected it. From the experiments of Mr. Cavendiſh it appears well eſtabliſhed that this ſubſtance enters into the compoſition of nitrous acid, by combining with vital air; and from the experiments of Berthollet and others it is ſhewn, that with inflammable air it forms volatile alkali. See ACID NITROUS, AIR ALKALINE, and the articles thence referred to. M. De Fourcroy propoſed to call it *alkaligene*; but the nomenclators, conſidering the analyſis not to be ſufficiently advanced to aſcertain with preciſion the manner in which this ſubſtance enters into the compoſition of acids and alkalis, preferred the term *azote*, derived from its property of extinguiſhing animal life.

The ſecond claſs, containing ſubſtances whoſe principal character is that of paſſing to the ſtate of acidity, is much more extended. But as it is likewiſe more uniform in its diſtinctive attributes, M. De Morveau thought it unneceſſary to mention more than a few of thoſe ſubſtances in his Memoirs.

In this claſs it may be obſerved that ſome of the acidifiable baſes are known,

but that the greater number of acids are ſuch whoſe conſtituent parts have not yet been ſeparated. The known acidifiable baſes are azote, or the baſe of nitrous acid; carbone, or that principle which conſtitutes the greater part of vegetable coal, and is admitted by theſe chemiſts, from the experiments of M. Lavoiſier, to form the baſis of carbonic acid, or fixed air; ſulphur, or the baſis of vitriolic acid; and phoſphorus, or the baſis of phoſphoric acid. The combinations of theſe baſes are the moſt numerous, the moſt familiar, and the moſt eaſy to be purſued; for which reaſons the French chemiſts eſtabliſhed their nomenclature by attending to them. With regard to the others, ſuch as the baſes of the marine acid, the acid of borax, the acid of vinegar, and the like, they were contented merely to denote the ſimple ſubſtance which modifies the oxygene by the expreſſion *acidifiable baſis*, or, more conciſely, the *radical of the acid*. It is probable, as M. Morveau obſerves, that many of theſe acids may have compounded baſes; or that their baſes may no otherwiſe differ from each other than in the proportion of the ſame principles. When analyſis ſhall have diſcovered theſe firſt elements, and the order of their application to each other, it will no doubt be proper to arrange them according to the nomenclature of the other known ſubſtances.

M. Morveau accordingly proceeds to explain the nomenclature of the products or combinations which have ſulphur for their origin.

Since ſulphur, by combining with oxygene, produces an acid, it is evident that the name ought to be derived from the name of the baſe. But as this acid is exhibited in two ſtates of ſaturation, in each of which its properties are different, it became neceſſary to apply a name to each of theſe ſtates, which, conſtantly preſerving the primitive root, ſhould, nevertheleſs, mark this difference. It was equally requiſite that the ſame demarcation ſhould follow all the ſaline compounds of theſe two acids. Again, it was neceſſary to attend to ſulphur in its other direct combinations, as for example, with earths, alkalis, and metals. Five different terminations, adapted to the ſame radical word, will diſtinguiſh theſe five ſtates of the ſame principle.

The *ſulphuric* acid will denote ſulphur in the utmoſt degree of ſaturation with oxygene. It is the vitriolic acid, as commonly denominated.

The *ſulphureous* acid will expreſs ſulphur united with a ſmaller proportion of oxygene. It is the volatile ſulphureous vitriolic acid, or the phlogiſticated vitriolic acid, formerly ſo called.

Sulphat will be the generic name of all the ſalts formed by the ſulphuric acid.

Sulphite will be the name of the ſalts formed of the ſulphureous acid.

Sulphure will be the name of all the combinations of ſulphur not in the ſtate of acidity. In this way one uniform denomination will be ſubſtituted inſtead of the improper and diſcordant names of liver of ſulphur, hepar, pyrites, mat, &c.

From this explanation and the general table annexed, it will be readily ſeen how the other combinations of the acid baſes are arranged and denominated.

The third diviſion of the general table comprehends all the metallic ſubſtances at that time known. The uranite or uranium diſcovered by profeſſor Klaproth, and announced in the year 1790, is therefore not among them. There were cogent reaſons not to change the names of thoſe ſubſtances. The metallic calces are called oxides. Such as are capable of acidification follow the general rule of other acid baſes in their terminations, as may be ſeen in the articles ARSENIC, MOLYBDENA, and TUNGSTEN. Compounds of metals with metals are called alloys.

The fourth general diviſion comprehends the five well known earths. The combinations

binations of theſe with the preceding ſubſtances have been already ſpoken of. The three new earths, viz. thoſe obtained from adamantine ſpar, and the jargon of Ceylon by Mr. Klaproth, and that from the mineral analyſed by Wedgewood, obtained from New South Wales, are not inſerted, as the date of their diſcovery is ſubſequent to the formation of this nomenclature.

The three alkalis occupy the fifth and laſt principal diviſion.

In the appendix of more compounded ſubſtances, we find mucus, gluten, ſugar, ſtarch, fixed oil, volatile oil, aroma, or the principle of ſmell in plants and flowers, reſin, extract, extracto-reſinous matter, reſino-extractive matter, fecula, alcohol, the compounds of alcohol, ethers, ſoaps.

It will be obſerved in the table, that it is divided into ſix vertical double columns, under the title of 1. Subſtances not decompoſed. 2. Converted into the ſtate of gas by caloric. 3. Combined with oxygene. 4. Gazeous oxygenated. 5. Oxygenated with baſes. 6. Combined without being converted into the acid ſtate. Theſe columns are double, in order that the firſt compartment may contain the new name, and the ſecond the correſpondent old name. Every horizontal diviſion exhibits the different ſtates and compounds of the ſimple ſubſtance which is at its head or commencement.

TABLE OF TH

Proposed by Messrs. De Morveau, Lavoi

		I. SUBSTANCES NOT DECOMPOSED.		II. CONVERTED INTO THE STATE OF GAS BY CALORIC.		III. COMBINED WITH OXYGEN	
		NEW NAMES.	ANCIENT NAMES.	*NEW NAMES.*	ANCIENT NAMES.	*NEW NAMES.*	ANCIENT NAM
1	ACIDIFIABLE BASES.	Light.					
2		Caloric.	*Latent heat*, or *the matter of heat.*				
3		Oxygene.	*Base of vital air.*	Oxygenous gas. *N. B.* It appears that light assists to change it into the state of gas.	*Dephlogisticated air*, or *vital air.*		
4		Hydrogene.	*Base of inflammable gas.*	Hydrogenous gas.	*Inflammable gas.*	Water.	*Water.*
5		Azote, *or* the Nitric radical	*Base of phlogisticated air*, or *of the atmospherical mofet.*	Azotic gas.	*Phlogisticated air*, or *atmospherical mephitis.*	Base of nitrous gas. Nitric acid. *And with excess of azot*, Nitrous acid.	*Base of nitrous gas.* *Colourless nitrous ac* *Fuming nitrous acid.*
6		Carbon, *or* the Carbonic radical.	*Pure charcoal.*			Carbonic acid.	*Fixed air*, or *cretaceo*
7		Sulphur, *or* the Sulphuric radical.				Sulphuric acid. *And with less oxygene*, Sulphureous acid.	*Vitriolic acid.* *Sulphureous acid.*
8		Phosphorus, *or* the Phosphoric radical.				Phosphoric acid. *And with less oxygene*, Phosphorous acid.	*Phosphoric acid.* *Fuming*, or *volatile phoric acid.*
9		Muriatic radical.				Muriatic acid. *And with excess of oxygene*, Oxygenated muriatic acid.	*Marine acid.* *Dephlogisticated mar*
10		Boraxic Radical.				Boraxic acid.	*Sedative salt.*
11		Fluoric radical.				Fluoric acid.	*Acid of spar.*
12		Succinic radical.				Succinic acid.	*Volatile salt of ambe*
13		Acetic radical.				Acetous acid, *And with more oxygene*, Acetic acid.	*Distilled vinegar.* *Radical vinegar.*
14		Tartaric radical.				Tartareous acid.	
15		Pyro-tartaric radical.				Pyro-tartareous acid.	*Empyreumatic ta acid*, or *spirit of*
16		Oxalic radical.				Oxalic acid.	*Saccharine acid.*

HEMICAL NOMENCLATURE.

thollet, and De Fourcroy, in May, 1787.

IV. GAZEOUS OXYGENATED.		V. OXYGENATED WITH BASES.		VI. COMBINED WITHOUT BEING CONVERTED INTO THE ACID STATE.		
EW NAMES.	ANCIENT NAMES.	*NEW NAMES.*	ANCIENT NAMES.	*NEW NAMES.*	ANCIENT NAMES.	
						1
						2
						3
						4
us gas.		Nitrate of potash.	*Common nitre.*			
		Nitrate of soda, &c.	*Cubic nitre.*			5
us acid gas.		Nitrite of potash.				
onic acid gas.	*Fixed air, mephitic air.*	Carbonate { of lime. of potash, &c. of iron.	*Chalk.* *Aerate alkalies.* *Ruft of iron.*	Carbure of iron.	*Plumbago.*	6
		Sulphate { of potash. of soda. of lime. of alumine. of barytes. of iron, &c.	*Vitriolated tartar.* *Glauber's salt.* *Selenite.* *Alum.* *Ponderous spar.* *Vitriol of iron.*	Sulphure { of iron. of antimony. of lead, &c.	*Factitious pyrites of iron.* *Antimony.*	
				Sulphuratedhydrogenous gas	*Hepatic gas.*	
				Sulphure of potash. } — Sulphure of soda, &c. }	*Alkaline livers of sulphur.*	7
				Alkaline sulphures containing metals.	*Metallic liver of sulphur.*	
hureous acid gas.	*Sulphureous acid gas.*	Sulphite of potash, &c.	*Stahl's sulphureous salt.*	Alkaline sulphures containing charcoal.	*Liver of sulphur containing charcoal.*	
		Phosphate { of soda. of lime, &c.	*Phosphoric salt with base of natrum.* *Earth of bones.*			8
		Phosphat super-saturated with soda.	*Haupt's pearly salt.*	Phosphorized hydrogenous [gas.	*Phosphoric gas.*	
		Phosphite of potash, &c.		Phosphure of iron.	*Syderite.*	
iatic acid gas.	*Marine acid gas.*	Muriate { of potash. of soda. of lime, &c. of ammoniac.	*Febrifuge salt of Sylvius.* *Sea-salt.* *Calcareous sea-salt.* *Sal ammoniac.*			9
genated muriatic acid as.	*Dephlogisticated marine acid gas.*	Oxygenated muriate of soda, &c.				
		Borat super-saturated with soda, *or* borax.	*Common borax.*			10
		Borate of soda, &c. *the soda saturated with acid.*				
oric acid gas.	*Sparry acid gas.*	Fluate of lime, &c.	*Fluor spath.*			11
		Succinate of soda, &c.				12
		Acetite { of potash. of soda. of lime. of ammoniac. of lead. of copper.	*Terra foliata tartari.* *Mineral foliated earth.* *Calcareous acetous salt.* *Mindererus's spirit.* *Sugar of lead.* *Verdegrise.*			13
		Acetat of soda, &c.				
		Acidulous tartrite of potash.	*Cream of tartar.*			14
		Tartrite of potash.	*Vegetable salt.*			
		Tartrite of soda, &c.	*Salt of Seignette.*			
		Pyro-tartrite of lime.				15
		Pyro-tartrite of iron, &c.				
		Acidulous oxalate of potash.	*Salt of sorrel.*			16
		Oxalat of lime. of soda, &c.				

		I. SUBSTANCES NOT DECOMPOSED.		II. CONVERTED INTO THE STATE OF GAS BY CALORIC.		III. COMBINED WITH OXYGEN	
		NEW NAMES.	ANCIENT NAMES.	*NEW NAMES.*	ANCIENT NAMES.	*NEW NAMES.*	ANCIENT NAM
17	ACIDIFIABLE BASES *continued.*	Gallic radical.				Gallic acid.	*Aſtringent principle.*
18		Citric radical.				Citric acid.	*Lemon-juice.*
19		Malic radical.				Malic acid.	*Acid of apples.*
20		Benzoic radical.				Benzoic acid.	*Flowers of benzoin.*
21		Pyro-lignic radical.				Pyro-ligneous acid.	*Spirit of box.*
22		Pyro-mucic radical.				Pyro-mucous acid.	*Spirit of honey, of &c.*
23		Camphoric radical.				Camphoric acid.	
24		Lactic radical.				Lactic acid.	*Acid of milk.*
25		Saccho-lactic radical.				Saccho-lactic acid.	*Acid of the ſugar of*
26		Formic radical.				Formic acid.	*Acid of ants.*
27		Pruſſic radical.				Pruſſic acid.	*Colouring matter of P blue.*
28		Sebacic radical.				Sebacic acid.	*Acid of fat.*
29		Lithic radical.				Lithic acid.	*Acid of the ſtone of the*
30		Bombic radical.				Bombic acid.	*Acid of ſilk worms.*
31	METALLIC SUBSTANCES.	Arſenic.	*Regulus of arſenic.*			Oxide of arſenic. *And with more oxygene,* Arſenic acid.	*White arſenic, or arſenic.* *Arſenical acid.*
32		Molybdena.				Oxide of molybdena. Molybdic acid.	*Calx of molybdena.*
33		Tungſtein.				Oxide of tungſtein. Tungſtic acid.	*Yellow calx of tunſt tungſtein.*
34		Manganeſe.	*Regulus of manganeſe.*			White, Black, Vitreous } Oxide of manganeſe.	*Manganeſe.*
35		Nickel.				Oxide of nickel.	*Calx of nickel.*
36		Cobalt.	*Regulus of cobalt.*			Grey oxide of cobalt. Vitreous oxide of cobalt.	*Calx of cobalt.*
37		Biſmuth.				White, Yellow, Vitreous } Oxide of biſmuth	*Magiſtery of biſmuth.* *Yellow calx of biſmu* *Glaſs of biſmuth.*
38		Antimony.	*Regulus of antimony.*			White oxide of antimony { by the nitrous acid. / by the muriatic acid.	*Diaphoretic antimony* *Powder of algaroth.*
						White ſublimated oxide of antimony. Vitreous oxide of antimony.	*Flowers or ſnow of mony.* *Glaſs of regulus of an*
39		Zink.				Oxide of zink. Sublimated oxide of zink.	*Calx of zink.* *Flowers of zink. Po lix, &c.*
40		Iron.				Black oxide of iron. Red oxide of iron.	*Ethiops of iron.* *Aſtringent ſaffron of*
41		Tin.				White oxide of tin.	*Calx of tin.*
42		Lead.				White oxide of lead. Yellow oxide of lead. Red oxide of lead. Vitreous oxide of lead.	*Ceruſſe, or white-lead* *Maſſicot.* *Minium.* *Litharge.*
43		Copper.				Red oxide of copper. Green oxide of copper. Blue oxide of copper.	*Brown calx of copper* *Green calx of copp verdegriſe.* *Mountain blue.*
44		Mercury.				Blackiſh, Yellow, Red } Mercurial oxide.	*Ethiops per ſe.* *Turbith mineral.* *Precipitate per ſe.*
45		Silver.				Oxide of ſilver.	*Calx of ſilver.*
46		Platina.				Oxide of platina.	*Calx of platina.*
47		Gold.				Oxide of gold.	*Calx of gold.*

IV. GAZEOUS OXYGENATED.		V. OXYGENATED WITH BASES.		VI. COMBINED WITHOUT BEING CONVERTED INTO THE ACID STATE.		
NEW NAMES.	ANCIENT NAMES.	*NEW NAMES.*	ANCIENT NAMES.	*NEW NAMES.*	ANCIENT NAMES.	
		Gallate { of soda. of magnesia. of iron.				17
		Citrate of potash. Citrate of lead, &c.	*Foliated earth with lemon-juice.*			18
		Malate of lime, &c.				19
		Aluminous benzoate. Benzoate of iron, &c.				20
		Pyro-lignite of lime. Pyro-lignite of zinc.				21
		Pyro-mucite of magnesia. Ammoniacal pyro-mucite, &c.				22
		Camphorate of soda, &c.				23
		Lactate of lime, &c.				24
		Saccholate of iron, &c.				25
		Ammoniacal formiat, &c.	*Spirit of magnanimity.*			26
		Prussiate of potash, &c.	*Phlogisticated alkali, or Prussian alkali.*			27
		Prussiate of iron, &c.	*Prussian blue.*			
		Sebate of lime, &c.				28
		Lithiate of soda, &c.				29
		Bombiate of iron, &c.				30
XIDES WITH DIFFERENT BASES.*						
ow { sulphurated oxide of arsenic. nical oxide of potash.	*Orpiment. Realgar. Liver of arsenic.*	Arseniate of potash, &c. Arseniate of copper, &c.	*Macquer's arsenical neutral salt.*	Alloy of arsenic and tin.	*Arsenicated tin.*	31
ur of molybden.	*Molybdena.*	Molybdate.		Alloy, &c.		32
		Calcareous tungstate.	*Tungsten of the Swedes.*	Alloy, &c.		33
				Alloy of manganese and iron.		34
				Alloy of nickel, &c.		35
line cobaltic oxides.	*Precipitates of cobalt re-dissolved by alkalies.*			Alloy, &c.		36
urated oxide of bis-uth.	*Bismuth precipitated by liver of sulphur.*			Alloy, &c.		37
ge } sulphurated oxide of anti-ous } mony. line oxide of anti-ony.	*Gray calx of antimony. Kermes mineral. Golden sulphur of antimony Glass and liver of antimony*			Alloy, &c.		38
urated oxide of zinc.	*Precipitate of zinc by liver of sulphur.*			Alloy, &c.		39
urated oxide of iron.				Alloy, &c.		40
w sulph. oxide of tin	*Aurum musivum.*			Alloy, &c.		41
urated oxide of lead.				Alloy, &c.		42
oniacal oxide of cop-r.				Alloy, &c.		43
{ sulphuratedoxide of mercury.	*Ethiops mineral. Cinnabar.*			Alloy or amalgam of, &c.		44
urated oxide of silver				Alloy, &c.		45
				Alloy of platina and gold.		46
				Alloy, &c.		47

* As the substances placed in the inferior part of this column cannot be changed into the state of gas as well as many of those situated above them; we have anged the title of this column, and by many of that which we have substituted we express certain combinations of metals.—Note by the Author.

		I. SUBSTANCES NOT DECOMPOSED.		II. CONVERTED INTO THE STATE OF GAS BY CALORIC.		III. COMBINED WITH OXYGEN	
		NEW NAMES.	ANCIENT NAMES.	*NEW NAMES.*	ANCIENT NAMES.	*NEW NAMES.*	ANCIENT NAM
48	EARTHS.	Silex.	*Vitrifiable earth, quartz, &c.*				
49	EARTHS.	Alumine.	*Argillaceous earth, or earth of alum.*				
50	EARTHS.	Barytes.	*Barytes, ponderous earth.*				
51	EARTHS.	Lime.	*Calcareous earth.*				
52	EARTHS.	Magnesia.					
53	ALKALIES.	Potash.	*Vegetable fixed alkali, salt of tartar. &c.*				
54	ALKALIES.	Soda.	*Mineral alkali. Marine alkali. Natrum.*				
55	ALKALIES.	Ammoniac.	*Fluor, or caustic volatile alkali.*	Ammoniacal gas.	*Alkaline gas.*		

NAMES GIVEN TO SEVERAL MORE COMPOUND SUBSTANC

	1	2	3	4	5	6	7	8	9	10
NEW NAMES.	Mucus.	Gluten.	Sugar.	Starch.	Fixed oil.	Volatile oil.	Aroma.	Resin.	Extract.	Extracto-r matter, w *extract pr nates*
ANCIENT NAMES.	*Mucilage.*	*Glutenous matter.*	*Saccharine matter.*	*Amylaceous matter.*	*Unctuous, or fat oil.*	*Essential oil.*	*Spiritus rector.*	*Resin.*	*Extractive matter.*	

IV. GAZEOUS OXYGENATED.		V. OXYGENATED WITH BASES.		VI. OMBINED WITHOUT BEING CONERTED INTO THE ACID STATE.		
IEW NAM S.	ANCIENT NAMES.	*NEW NAMES*	ANCIENT NAMES	*NEW NAMES.*	ANCIENT NAMES.	
						48
						49
						50
						51
						52
						53
						54
						55

WHICH COMBINE WITHOUT DECOMPOSITION.

11	12	13	14	15	16	17
sino-extractive tter, *when the esin predominates.*	Fecula.	Alcohol, *or* Spirit of wine.	Alcohol { of potash. of guaiacum. of scammony. of myrrh, &c.	Nitrous alcohol. Gallic alcohol. Muriatic alcohol.	Sulphuric ether. Muriatic ether. Acetic ether, &c.	Alkaline soaps. Earthy soaps. Acid soaps. Metallic soaps. Saponul of turp. &c.
	Fecula.	*Spirit of wine.*	*Alkaline tincture.* Tincture { *of guaiacum. of scammony. of myrrh, &c.*	*Dulcified spirit of nitre. Tincture of galls. Dulcified marine acid.*	*Frobenius's ether. Marine ether. Acetous ether, &c.*	*Alkaline soaps. Earthy soaps, &c. Combinations of the volatile oils with different bases.*

NORKA. A compound ſtone of the ſiliceous genus, being a variety of the granite or moor-ſtone. It is either grey or reddiſh, and conſiſts of quartz, garnet, and mica. It is uſed for mill-ſtones.

NUTMEGS. This fruit contains two kinds of oils, namely, a groſs ſebaceous oil, and a volatile eſſential fluid oil; in which laſt the peculiar taſte and ſmell of nutmegs reſide. The eſſential oil alſo appears to be of two kinds; one of which is ſo light as to ſwim upon water, and to riſe in diſtillation with ſpirit of wine; and the other is ſo groſs and ponderous, that it ſinks in water, and is with difficulty capable of being diſtilled with water, and not at all with ſpirit of wine.

Sixteen ounces of nutmegs yielded, by diſtillation, half an ounce of eſſential oil; and afterwards four or five ounces of the groſs ſebaceous oil were found floating on the ſurface of the water in the ſtill. Rectified ſpirit of wine diſſolves all the eſſential oil, and a part of the expreſſible oil. From four ounces of nutmegs nine drams of a concrete oil were expreſſed. This oil contains a conſiderable portion of the eſſential oil. It is brought from India in form of cakes, and is called oil of mace, the mace being one of the exterior coverings of the nutmeg, and containing ſimilar oils. Neumann.

NUX VOMICA, ſo called, is not a nut, but the ſeed of a fruit like an orange, growing in the Eaſt Indies: it is called by the Germans kræhenaugen, crows'-eyes, from its having ſomewhat of the appearance of a grey eye, and from its being poiſonous to crows. The tree is deſcribed and figured in the *Hortus Malabaricus*, under the name of Caniram. The ſeeds brought to us are of different ſizes, and produced by different ſpecies of the plant. The tree which yields the ſmaller ſort is that whoſe roots are the lignum colubrinum of the ſhops. They are commonly of a roundiſh flat figure, variouſly bent, with a navel or prominence in the middle covered all over with fine ſhort hairs like velvet; the kernel is nearly of the conſiſtence of horn, but harder and more brittle, ſo as to be beat in pieces by a hammer.

An ounce of nux vomica, raſped into fine powder, yielded with water half an ounce of gummy extract, and afterwards with ſpirit only five grains of reſin; another ounce, treated firſt with ſpirit, gave one dram 32 grains of reſinous extract, and afterwards two drams 36 grains of mucilage; the indiſſoluble part amounting to about half the weight of the ſeed. Both the watery and ſpirituous extracts, prepared at firſt, are very bitter, particularly the ſpirituous: thoſe made by either menſtruum, after the other has performed its office, have little bitterneſs. In diſtillation neither water nor ſpirit brings over any thing remarkable. The watery ſpirit of ſal ammoniac digeſted on this ſeed, gains a deeper colour than any other menſtruum; the tincture is browniſh red. The vinous ſpirit of ſal-ammoniac ſcarcely extracts a yellowiſh hue; and ſimple ſpirit of wine receives no tinge at all.

Nux vomica is poiſonous to dogs, to other carnivorous animals and ſuch as are born blind. It does not indeed follow, from hence, that it is poiſonous to men; and ſome have even recommended it as a notable diaphoretic and alexipharmic; and Melichius obſerves that it is eaten by the Turks without injury. But Seutter tells us of a woman in Holland, who, on taking a doſe of nux vomica, mixed with a little gentian, for the cure of an intermitting fever, was thrown into violent convulſions, from which ſhe difficultly eſcaped with her life: this one example is ſufficient to deter us from the uſe of the nux vomica, eſpecially as we are furniſhed with efficacious and unſuſpected medicines for all the intentions in which it is recommended. It is obſervable, that the outer ſkin, and its hairy covering, are more virulent than the kernel. Neumann.

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OAK. The uſes of the wood of the oak tree are ſufficiently known. Every part of this vegetable abounds with aſtringent matter; but the ſubſtances more particularly attended to by chemiſts are, the excreſcence of the oak, called the nut gall, of which we have already treated under the articles ACID OF GALLS, and INK; and the bark of the tree, uſed in the proceſs of tanning, which ſee.

OCHRE. A ferruginous earth, or ore of iron, commonly of a yellow, brown, or red colour. It is uſed as a pigment. The colour of ſuch ſpecimens as are dark, may be rendered of a brighter red by calcination; which alters the ſtate of the metal. Ochres appear to have been produced by the decompoſition of the martial pyrites, which conſiſt of ſulphur and iron. By the combined action of the air and water, the ſulphur becomes acidified, and forms vitriol, the iron of which may be depoſited upon calcareous earths, which ſeize the acid: or more commonly, by the more complete calcination of the iron, by the air, which then becomes leſs ſoluble and falls down, as is ſeen in a ſolution of common vitriol left in an open veſſel. In many places the iron is extracted from this ore.

OCULUS MUNDI. See HYDROPHANES.

ODOUR. See SMELL, PRINCIPLE OF.

OFFA ALBA, OR OFFA HELMONTII. When ſtrong ardent ſpirit is added to a ſolution of mild volatile alkali in water, the ſalt is precipitated in conſequence of the ſtrong attraction of the ſpirit for the water. No ſuch precipitation takes place when the alkali is cauſtic, becauſe the pure alkali is itſelf ſoluble in the ſpirit, whether it be exhibited in the form of air, or the aqueous ſolution.

OIL. The diſtinctive characters of oil are, inflammability, inſolubility in water, and fluidity, at leaſt in a moderate temperature. They are diſtinguiſhed into fixed oils, or fat oils, which do not riſe in diſtillation at the temperature of boiling water, and volatile or eſſential oils, which do riſe at that temperature.

Fixed oils are obtained by preſſure from the emulſive ſeeds or kernels of vegetables; they are generally fluid in the temperature of the atmoſphere, but ſome of them have a conſiderable degree of firmneſs or ſolidity. They have a very ſmooth feel; are moſtly without ſmell or taſte; require a degree of heat much ſuperior to that of boiling water, to cauſe them to riſe in ebullition; and cannot be ſet on fire, unleſs heated to this degree. The uſe of the wick of a lamp conſiſts in bringing ſmall portions of oil to its extremity, by the capillary attraction; where they become ſucceſſively volatilized and inflamed. Oils are remarkably leſs ſonorous than water, when poured out. Fat oils, not being at all diſſipated by the heat of the atmoſphere, make a permanent greaſy ſpot when they fall on porous ſubſtances.

Theſe oils are decompoſed by diſtillation, and afford a ſmall quantity of water loaded with a peculiar acid, a light oil, a denſe oil, inflammable air, and fixed air. The reſidue conſiſts of a ſmall quantity of charcoal.

In the laſt analyſis of organiſed ſubſtances the reſults are, inflammable air, vital air, phlogiſticated or azotic air, and fixed air, or pure coal, which appears to be its baſis. By what combinations or ſuper-compoſitions they are made to exhibit

the variety of products which come under our obſervation, can in few reſpects be aſcertained by any experiments we are yet capable of making. Lavoiſier, in the Memoirs of the French Academy for 1784, collected the products of olive oil burned in an apparatus properly conſtructed to aſcertain their nature and properties. He obtained 79 parts of carbone, and 21 of hydrogene, from 100 of the oil. From theſe component parts, inferences may be formed reſpecting the acid, the water, the fixed air, and the inflammable air, afforded by the partial decompoſitions or combuſtions of this fluid.

The light oil produced by diſtillation of fat oils, is naturally more diſpoſed to fly off by heat, and leaves leſs coal behind it, than the fat oil itſelf. This property renders it uſeful in ſome of the arts, as thoſe of lapidaries, ſeal-engravers, and others, who grind precious ſtones with fretting powders. The oil uſed for this purpoſe is known by the name of oil of bricks, and is made, as I am informed, by igniting pieces of brick, quenching them in olive oil, and afterwards diſtilling the oil from the pieces of brick which had imbibed it. In order to form a proper notion of the advantage of this fluid, it muſt be remarked, that all grinding produces heat; that this heat would ſpeedily evaporate water, and render common oil thick; that, if neither water nor oil were preſent, the heat would very ſoon increaſe to ſtrong ignition, and injure both the tool and the ſubſtance operated on. The oil of bricks poſſeſſes neither of the bad qualities of the two fluids here mentioned, in ſo conſiderable a degree, and is therefore preferred for ſuch work as can afford the expence.

Fat oils, by expoſure to the air, become rancid, and exhibit a diſengaged acid, which may be waſhed off by water. When they are expoſed to the air, in a thin coat, upon the ſurface of water; they become more conſiſtent, like wax, by abſorbing the vital part of the atmoſphere. The aerated or dephlogiſticated marine acid produces this change more ſpeedily. Agitation in water ſeparates a mucilage from them. They combine with magneſia, and with lime, which convert them into ſaponaceous compounds. With the pure alkalis they form common ſoap. They do not unite with the volatile alkali, but by long trituration.

The mineral acids unite with fat oils, and form compounds, or imperfect ſoaps. Fuming nitrous acid cauſes them to take fire, as has already been obſerved. Sulphur is ſoluble in fat oils, by a digeſting heat; and is gradually depoſited in part from them, in a cryſtalline form, by cooling.

Theſe ſulphureous compounds are called balſams of ſulphur.

Fixed oils ſeem not to be ſuſceptible of combination with pure metallic ſubſtances, excepting iron and copper, upon which they act in a ſufficiently diſtinct manner. But they combine with metallic calces, and form with them thick concrete combinations, of a ſoapy appearance, as is obſervable in the preparation of unguents and plaſters. Theſe preparations have not been yet chemically examined: only we know, that ſome metallic calces are reduced in the making up of plaſters; as for inſtance, the calx of copper in the Divine Plaſter, and litharge, or calx of lead, in the Ointment *de la Mere*. In the aſſaying of metals, fixed oils are employed to reduce the metallic calces. M. Berthollet has given an ingenious and ſimple proceſs for effecting inſtantaneouſly a real combination between fixed oil and any metallic calx, that is, for preparing a metallic ſoap. It conſiſts in pouring a metallic ſolution into a ſolution of common ſoap. The acid of the metallic ſolution combines with the fixed alkali of the ſoap; and the metallic calx is then precipitated in union with the oil, to which it communicates a colour. In this manner, ſoap of a beautiful green colour may be prepared

with vitriol of copper; and with vitriol of iron, a clear deep brown ſoap. Fourcroy thinks theſe compounds might be very uſeful in painting.

Scheele has diſcovered, that when oil of ſweet almonds, olives, rape-ſeed, or lint-ſeed, is combined with calx of lead, with the addition of a little water, there is a matter ſeparated from the oil which ſwims on the ſurface of the liquor, and to which he has given the name of the mild principle. On evaporating this ſupernatant water, the principle diſſolved in it cauſes it to take the conſiſtency of ſyrup: when expoſed to a ſtrong heat, it takes fire: one part is volatilized in diſtillation, without burning: the coal which it leaves is light: it does not cryſtallize; nor does it ſeem to be ſuſceptible of fermentation. Nitrous acid, diſtilled on this matter four times ſucceſſively, changes it into acid of ſugar. This mild principle of Scheele's appears to be a ſort of mucilage.

The denſe animal oils, ſuch as butter, tallow, fat, the oil of the whale, and the like, exceedingly reſemble vegetable fixed oils. They appear, however, to contain a proportion of azotic air, or animalized matter, probably in the ſtate of ſerum or jelly. The volatile oil obtained by attenuating animal oil, by a number of ſucceſſive diſtillations, is called the oil of Dippel. Macquer obſerves, that it may be rendered almoſt as white, thin, and volatile, as ether, and is then capable of acting upon the brain and nervous ſyſtem, in a doſe of from four to ten or twelve drops, incorporated with ſome proper vehicle.

It is much more difficult to obtain this oil in a pure ſtate from fixed oils, than from gelatinous matters, of which hartſhorn is to be preferred. It is neceſſary to change the veſſels at each ſucceſſive diſtillation, or elſe to clean them perfectly, becauſe a very ſmall part of the thicker and leſs volatile oil is ſufficient to ſpoil a large quantity of that which is more highly rectified. Beaumé has obſerved, that this operation may be greatly abridged by taking care to receive none but the moſt volatile part in each diſtillation, and to leave a large reſiduum, which is to be neglected, and only the more volatile part is to be further rectified. By this method, we may obtain in three or four diſtillations a conſiderable quantity of fine oil of Dippel, which could not be obtained after 50 or 60 diſtillations, without attending to this circumſtance. And Monnet aſſerts, that, by mixing acids with animal oil, their rectification may be very much facilitated.

The oil of Dippel muſt be kept in clean glaſs bottles with ground ſtoppers, and expoſed as little as poſſible to the air, becauſe its volatile parts fly off, and the remainder becomes coloured.

Fourcroy diſtinguiſhes vegetable fat oils into three claſſes. In the firſt, he places ſuch as are congealable by cold, thicken very ſlowly by expoſure to air, form ſoaps with acids, and require an addition of vitriolic acid to that of nitre in order to inflame them. Such are,

1. Oil of olives, obtained by bruiſing that fruit between two mill-ſtones, and preſſing it in bags made of ruſhes. That which runs firſt is called virgin oil; that which is obtained from mark ſprinkled with water is not ſo pure, and depoſits a lee; that obtained from unripe olives is the *oleum omphacinum* of the ancients. Oil of olives freezes at 10° under zero, in Reaumur's thermometer, or 10½ above that point in Fahrenheit's, and will ſtand about twelve years without becoming rancid.

2 Oil of ſweet almonds, extracted without the application of heat, becomes very ſoon rancid; it freezes at 6° under 0 in Reaumur's ſcale, or 17½ of Fahrenheit's.

3. Oil of rape-ſeed, obtained from the ſeed of a kind of cabbage, called colſa.

4. Oil

4. Oil of ben, extracted from the ben nut of Egypt and Arabia; it is very acrid, and deſtitute of ſmell; it freezes very eaſily.

The ſecond claſs comprehends oils ſubject to become dry, which are very eaſily rendered thick, are not fixed by the action of cold, are kindled by the nitrous acid, and form with vitriolic acid a ſort of reſin. Such are,

1. Lint-ſeed oil, obtained by preſſure from lint-ſeed; it is uſed for oily varniſhes, and in painting.

2. Oil of nuts, applied to the ſame uſes.

3. Oil of carnations, or poppy-ſeed; which, as has been fully proved by the Abbé Rozier, is not at all narcotic.

4. Oil of hemp-ſeed, which is very drying.

Under the third genus, he comprehends concrete fixed oils, or vegetable butters; among which may be diſtinguiſhed the following:

1. Butter of cacao, extracted from the cacao nut.—There are four ſorts of cacao; the large and the ſmall caracca, the berbice, and that of the iſlands: this butter is extracted from the nut by roaſting, and ſubſequent boiling in water; it is purified by melting it by a very moderate heat.

2. The cocoa nut affords a ſimilar butter.

3. Vegetable wax is of the ſame nature, only more ſolid. It is the production of China; it is there made into yellow, white, or green candles, the colour varying with the manner in which the wax is extracted. The catkins of birch and poplar afford a ſmall quantity of a ſimilar wax; that of Louiſiana is more plenteous. M. Berthollet eaſily whitens it with oxygenated muriatic acid.

Volatile or eſſential oils have uſually a ſtrong aromatic ſmell, are ſufficiently volatile to riſe with the heat of boiling water, and are in general ſoluble in ſpirit of wine. They exiſt in almoſt all fragrant vegetables; and in the various plants which ſupply them they are found either in the wood, the root, the bark, the leaves, the flowers, the fruits, &c. They differ very much in the degree of fluidity they poſſeſs at a common temperature, and their colours are various. They are obtained either by expreſſion, as from the peel of oranges and lemons, or by diſtillation with water. Some eſſential oils, ſuch as thoſe of cinnamon, ſaſſafras, and other foreign plants, ſink to the bottom of the water with which they come over; others float at the top. It is eaſy to diſtinguiſh the adulteration of volatile oils, either by pouring ardent ſpirit upon them, which will not diſſolve the fat oil they may be contaminated with; or if they be dropped on paper, and held to the fire, in this caſe they leave a greaſy ſpot behind. If oil of turpentine be fraudulently added to them, its ſmell betrays its preſence when treated in this manner.

Volatile oils are very inflammable; by expoſure to air they become thick in proceſs of time, and aſſume the character of reſins.

They unite with difficulty to lime and alkalis. The vitriolic acid converts them into bitumens; but, if diluted, it renders them ſaponaceous, as does likewiſe the muriatic acid. Nitrous acid inflames them.

They unite very readily with ſulphur, and form balſams. Mucilages and ſugar render them ſoluble or diffuſible in water.

Theſe oils not only contain all the ſmell, but ſometimes likewiſe the taſte of the body from which they have been extracted; in conſequence of which the reſiduum has loſt theſe ſenſible qualities. There are indeed ſeveral vegetables that have an agreeable flavour, and notwithſtanding yield no ethereal oil on being diſtilled with water, of which lilies, hyacinths, clove, july-flowers, violets, the bloom of the lime or linden-tree, lilies of the valley, &c. are uſually adduced as inſtances;

inſtances; a fact which might be oppoſed to what has been aſſerted juſt above. But this objection in the opinion of Wiegleb is eaſily overturned, as he thinks he is able to prove, that the reaſon why none of theſe ſubſtances yield ethereal oil, is only becauſe they contain but a ſmall, though a ſtrong-ſcented portion of this oil, which is imbibed by the water employed in the diſtillation; in conſequence of which, this likewiſe acquires the ſame ſmell as was originally poſſeſſed by the vegetable itſelf. Roſes, orange-flowers, and ſeveral other ſimilar ſubſtances, which contain but very little oil, were formerly ranked among theſe, as they alſo yield no oil, when in ſmall quantities; but it is now certainly known, that in large quantities they afford a ſmall portion of oil. We find likewiſe that vegetables, which are certainly known to contain volatile oil, when diſtilled in ſmall quantities, yield an odorous diſtilled water only, in which frequently not the leaſt veſtige of ſuch oil is diſcoverable. Wiegleb very rationally ſuppoſes that, if thoſe vegetables which produce an odorous water were ſubmitted to diſtillation by the hundred weight, they would yield an ethereal oil juſt as well as the others; and that we ſhould neceſſarily be convinced, that the whole of their ſmell is derived from a ſmall quantity of a ſtrong-ſcented ethereal oil.

The preſence of eſſential oils is diſcoverable by the ſmell. In theſe they are commonly in appropriated veſſels, which, however, are ſometimes ſo ſmall that they cannot be diſtinguiſhed by the naked eye, yet in ſome they may be obſerved by the aſſiſtance of microſcopes; as for inſtance, in nutmeg, angelica, and maſter-wort, juniper-berries, lemon and orange-peel. From theſe two laſt the Italians are accuſtomed to ſeparate the oil by expreſſion, by which means they preſerve their natural agreeable odour and taſte.

Eſſential oils are found in very different proportions in the ſubſtances which contain them. It is ſcarcely practicable to determine with accuracy the quantity of oil yielded by each ſubſtance; but it is a very deſirable thing even to know the proportions of them nearly. In this view, the following table from Wiegleb may be of uſe, which at leaſt will furniſh much information to ſuch as may wiſh to proſecute the ſubject.

TABLE exhibiting the Quantity of ETHEREAL OIL obtained from different VEGETABLES.

Name of the Vegetable.	Quantity.	Weight of the Oil.	Maker of the Experiment.
AGALLOCHUM wood —	10 lb	4 drachms	Hoffmann.
Angelica root — —	1 lb	1 drachm	Cartheuſer
Aniſeed —— —	1 lb	2 drachms	Neumann.
Aſſafœtida —— —	4 ounces	1 drachm	Ditto
Balm, common — —	6 baſkets	1 drachm	Dehne
—— Turkey — —	ditto	2 ounces	Dehne
Cajaput ſeeds —— —	1 lb	15 grains	Dehne
Calamus aromaticus —	50 lb	2 ounces	Hoffmann.
———— —	1 lb	2 ſcruples	Neumann.
Camomile flowers, common	1 lb	½ drachm	Cartheuſer
————	6 lb	5 drachms	Lewis
————	200 baſkets	1 lb	Dehne

Name of the Vegetable.	Quantity.	Weight of the Oil.	Maker of the Experiment.
Camomile flowers, wild —	1 lb	20 grains	Cartheuſer
———	6 lb	2½ drachms	Lewis
——— Roman —	30 lb	1¾ ounces	Dehne
Caraway ſeeds —— —	4 lb	2 ounces	
——— —	2 lb	9 drachms	Lewis
——— —	1 cwt	83 ounces	
Cardamum ſeeds — —	1 ounce	1 ſcruple	Neumann
Cariophilli Plinii —— —	½ lb	½ ounce	Dehne
Carliſle thiſtle root —	1 lb	2½ ſcruples	Neumann
Carrot ſeeds —— —	2 lb	1½ drachm	Lewis
Caſcarilla bark —— —	1 lb	1 drachm	Cartheuſer
——— —	30 lb	4 ounces	Dehne
Caſſiæ flores — —	1 lb	½ drachm	Cartheuſer
——— —	30 lb	4 ounces	Dehne
Cedar wood —— —	1 lb	2 drachms	Margraff
Chervil leaves — —	9 lb	½ drachm	Neumann
Cinnamon —— —	1 lb	1 drachm	Sala
——— —	1 lb	2½ ſcruples	Neumann
——— —	4 lb	6 drachms	Lemeri
——— —	1 lb	2 drachms	Cartheuſer
——— —	1 lb	8 ſcruples	Ditto
——— —	3 lb	4 drachms	Dehne
Clary (garden), the ſeeds —	4 lb	2 drachms	Lewis
—— in flower, freſh —	130 lb	3½ ounces	
Cloves —— —	1 lb	1½ ounce	Teichmeyer
——— —	1 lb	2¼ ounces	Cartheuſer
——— —	2 lb	5 ounces	Hoffmann
——— —	2 lb	5 ounces	
——— —	1 lb	1 oz 6 drach.	Dehne
——— —	1 lb	2½ ounces	
——— —	1 lb	2 oz 2 drach.	
Copaiba balſam —— —	1 lb	6 ounces	Hoffmann
——— —	1 lb	8 ounces	Lewis
Culilabani cortex — —	1 lb	1 drachm	Vogel
Cummin ſeed —— —	1 lb	5 drachms	Ditto
——— —	1 buſhel	21 ounces	Lewis
Dill ſeed —— —	4 lb	2 ounces	Ditto
——— with the tops —	6 baſkets	8 ounces	Dehne
Dittany of Crete —— —	1 lb	30 grains	Lewis
Elecampane root — —	2 lb	3½ ſcruples	Neumann
——— dry —	12 lb	3½ drachms	Dehne
Elemi (gum) —— —	1 lb	1 ounce	Neumann
Fennel ſeed (common) —	1 lb	8 ſcruples	Ditto
——— ſweet — —	1 buſhel	18 ounces	Lewis
Feverfew flowers —— —	1 baſket	2 drachms	Dehne
Galangal root —— —	1 lb	1 drachm	Cartheuſer
Garlic root, freſh — —	2 lb	30 grains	Neumann
Ginger —— —	1 lb	1 drachm	Ditto
Horſe-radiſh root — —	1 lb	15 grains	Vogel

Horſe-

Name of the Vegetable.	Quantity.	Weight of the Oil	Maker of the Experiment.
Horſe-radiſh root —	8 ounces	15 grains	Neumann
Hyſſop leaves —— —	2 lb	1½ drachm	Ditto
——— —	1 lb	ditto	Cartheuſer
——— —	1 lb	2 drachms	Ditto
——— —	2 cwt	6 ounces	Lewis
——— —	10 lb	3 drachms	
——— —	30 lb	9 drachms	
Juniper berries —— —	8 lb	3 ounces	Hoffmann
——— —	1 lb	3 drachms	Cartheuſer
——— —	48 lb	6 ounces	Dehne
——— —	60 lb	6¾ ounces	
——— wood —	15 lb	2 ounces	
Lavender, in flower, freſh —	48 lb	12 ounces	Lewis
——— —	30 lb	6¾ ounces	
——— —	13½ cwt	60 ounces	
——— —	2 lb	4 drachms	Hoffmann
——— dry —	4 lb	2 ounces	Lewis
——— —	2 lb	1 ounce	Hoffmann
——— —	4 lb	3 ounces	
——— broad-leaved, dry	4 lb	1 ounce	
——— —	1 lb	1 drachm	Cartheuſer
Lovage root —— —	1 lb	1 drachm	Ditto
Mace —— —	1 lb	5 drachms	Neumann
Marjoram in flower, freſh —	85 lb	3¾ ounces	Lewis
——— —	13½ lb	3½ drachms	
——— —	34 lb	1½ ounce	
——— leaves, freſh —	18 lb	½ ounce	
——— dry —	4 lb	1 ounce	Hoffmann
Maſterwort root —— —	1 lb	½ drachm	Neumann
Milfoil flowers — —	18 baſkets	4½ ounces	Dehne
——— dry — —	14 lb	4 drachms	Lewis
Mint in flowers, freſh —	6 lb	4½ drachms	Ditto
—— leaves, dry — —	4 lb	1½ ounce	Hoffmann
—— freſh —— —	30 baſkets	1¼ lb	Dehne
Mother of thyme — —	45 lb	4 drachms	Ditto
Myrrh —— —	1 lb	2 drachms	Hoffmann
——— —	1 lb	3 drachms	Neumann
Nutmegs —— —	1 lb	1 ounce	Hoffmann
——— —	1 lb	1 ounce	Geoffroy
——— —	1 lb	½ ounce	Neumann
——— —	1 lb	¾ ounce	Sala
——— —	1 lb	5 drachms	Cartheuſer
Parſley ſeeds —— —	2 lb	1 drachm	Lewis
——— leaves, freſh —	238 lb	2 ounces	Ditto
——— leaves, with the ſeeds	15 baſkets	14½ ounces	Dehne
Parſnep ſeeds —— —	8 lb	2 drachms	Lewis
Pennyroyal, in flower, freſh	13 lb	6 drachms	Ditto
Pepper, black —— —	2 lb	ditto	Ditto

Name of the Vegetable.	Quantity.	Weight of the Oil.	Maker of the Experiment.
Pepper, black —	1 lb	2½ drachms	Gaubius
——— —	1 lb	3 drachms	
——— —	1 lb	2½ drachms	Neumann
——— —	1 lb	4 ſcruples	Cartheuſer
——— Jamaica —	1 ounce	30 grains	Neumann
Peppermint, freſh —— —	4 lb	3 drachms	Lewis
Rhodium wood —— —	1 lb	3 drachms	Neumann
——— —	1 lb	2 drachms	Sala
——— —	1 lb	3 ditto	
——— —	1 lb	3 ditto	Cartheuſer
——— —	1 lb	4 ditto	
Roſes —— —	1 cwt	4 ditto	Tachenius
—— —	1 ditto	1 ounce	Homberg
—— —	12 lb	30 grains	Hoffmann
Roſemary, in flower —	1 cwt	8 ounces	Lewis
——— leaves —— —	1 lb	2 drachms	Sala
——— —	1 lb	3 ditto	
——— —	3 lb	3⅙ ditto	Neumann
——— —	1 lb	1 drachm	Lewis
——— freſh —	70 lb	5 ounces	Cartheuſer
Rue leaves —— —	10 lb	2 drachms	Hoffmann
——— —	10 lb	4 ditto	
—— in flower —	4 lb	1 drachm	
——— —	60 lb	2½ ounces	Lewis
—— with the ſeeds —	72 lb	3 ounces	
Saffron, oriental —— —	1 lb	5 ſcruples	Cartheuſer
Sage leaves —— —	34 lb	1½ ounce	Lewis
—— in flower, freſh —	27 lb	6 drachms	
—— of virtue, in flower —	1 lb	1½ drachm	Vogel
Saſſafras wood —— —	6 lb	1¾ ounces	Hoffmann
——— —	6 lb	2 ounces	Neumann
——— —	30 lb	7 oz 1 drach.	Dehne
——— —	24 lb	9 ounces	
Savin bark —— —	2 lb	5 ounces	Hoffmann
——— —	29 lb	9 ounces	Dehne
—— wood —— —	32 lb	½ ounce	
Saunders yellow —— —	1 lb	2 drachms	Cartheuſer
Scurvy graſs, in flower, freſh	6 baſkets	6 drachms	Dehne
Smallage ſeeds —— —	1 lb	10 grains	Neumann
Stachas, in flower, freſh —	5¾ lb	2 drachms	Lewis
Thyme, in flower, freſh —	2 cwt	5½ ounces	Lewis
——— dry —	3½ lb	1½ drachm	
—— (lemon) in flower, freſh	51 lb	1¾ ounces	
———	98 lb	2½ ounces	
——— a little dried —	104 lb	3 ounces	
Wormwood leaves, dry —	4 lb	1 ounce	Lewis
——— —	18 lb	1½ ounce	
Zedoary root —— —	1 lb	1 drachm	Neumann
——— —	7 lb	1 ounce	Dehne

When

When the quantity of oil inherent in any particular ſubſtance is to be aſcertained, it cannot be done directly on the firſt diſtillation, unleſs water were to be employed for this purpoſe, that is already impregnated with oil; becauſe the water that is diſtilled from an oleaginous body, for the firſt time, always imbibes a conſiderable portion of its ethereal oil, and thus renders the calculation erroneous.

Neither are vegetables impregnated with the ſame quantity of oil at all ſeaſons of the year; but herbs ſhould only be applied to this purpoſe, when they are in full bloſſom, and many of them when they are run to ſeed. The roots are moſt impregnated with oil juſt before they ſend forth their radicles in the ſpring, but woods at the beginning of the winter. The maceration of green vegetables is needleſs, and indeed rather detrimental than otherwiſe; whereas, on the contrary, with dry and ſolid bodies it may be more uſeful, in which caſe ſome common ſalt is added, in order to prevent fermentation taking place. When freſh vegetables poſſeſs no particular volatile ſmell, it is rather of uſe to let them wither a little. Oils that yield a volatile odour muſt be diſtilled over with a gentle heat; but, on the other hand, ſuch as at the ſame time are diſtinguiſhed by a greater ſpecific gravity, require a ſomewhat ſtronger fire for their diſtillation.

Moſt ethereal oils, it is true, ſwim upon the water with which they have come over in diſtillation; there are ſome, however, that ſink in it. The method of ſeparating the former is, firſt to leave the glaſs filled with the oily water at reſt for ſome days, and then, by ſhaking it gently, to bring the oil up to the ſurface of the water. It may then be taken off either with a tea ſpoon, or with a ſmall glaſs ſyringe. The beſt method, however, is to convey it by means of a ſhort and ſlender ſkane of cotton, from the glaſs in which it is firſt received, into another glaſs tied to the upper part of this, by which means, at the ſame time, all the impurities which are frequently to be found in theſe oils, adhere to the cotton, and the oil is obtained pure and clear. With reſpect to the other ſpecies of theſe oils, which ſink to the bottom in water, and are conſequently heavier than water, this latter fluid muſt be made heavier by another body; for which purpoſe, nothing more is neceſſary to be done than to impregnate the water ſtrongly with common ſalt, till the oil which lies at the bottom of the veſſel riſes to the ſurface, from whence it may then be ſeparated in the manner above mentioned.

When eſſential oils, brought nearer to the reſinous ſtate by time, but not yet entirely deprived of their peculiar ſmell, are diſtilled with the heat of boiling water, a part of them riſes in diſtillation, which has all the properties of eſſential oil freſhly diſtilled. As this portion of oil is renewed by this operation, it is frequently practiſed on eſſential oils, which begin to be altered by age; and this ſecond diſtillation is called the rectification of eſſential oils. We find in the cucurbit, after rectification, the reſinous portion of the oil, which is no longer capable of being raiſed by the heat of boiling water. This oily reſiduum may, however, be attenuated by diſtilling with a ſtronger heat, and even all the volatility and thinneſs of eſſential oils may be given to it, as in the oil of Dippel, as well as other oily matters, by diſtillations ſufficiently repeated. But ſuch oils have never the peculiar aromatic ſmell of the original eſſential oil.

Eſſential oils are employed in painting, in ſpirituous liquors, uſed at the table and at the toilette, in perfumes, and in medicine. As they act very powerfully, ſmall doſes only are given internally, as from one drop to four or five, incorporated with ſugar, ſo as to form an oleo-ſaccharum, or with other drugs in form of pills.

OILS (FETID EMPYREUMATIC).

Under this name are comprehended all the oils of vegetable and animal matters

obtained by diſtillation with a heat ſuperior to that of boiling water; becauſe theſe oils have a diſagreeable, burnt, or empyreumatic ſmell.

From this definition it is ſeen, that empyreumatic oils are not a diſtinct claſs: that they may be very different from each other, and may have nothing in common, but that they are all half-burnt; for when any vegetable or animal matter is expoſed to a degree of heat ſuperior to that of boiling water, all the oils which they contain, of whatever kind they may be, paſs in diſtillation; but are altered, by the fire, in their colour, ſmell, and in many other of their peculiar properties. Beſides, if the matter thus diſtilled contains ſeveral kinds of oils, they are all mixed together when they are rendered empyreumatic. If, for example, a vegetable matter be diſtilled which contains an oil that is ſweet and not volatile, and alſo an oil in a reſinous ſtate, the fetid empyreumatic oil obtained will be only a mixture of theſe two oils half-burnt. The ſame may be ſaid of animal matter, with regard to the oil properly called animal oil, and to the adipous oil which they contain.

No general properties, then, can be eſtabliſhed as belonging to empyreumatic oils: they all vary according to the nature and proportion of the oils of which they are compoſed. Hence, in order to know the properties of any empyreumatic oil, it is neceſſary previouſly to know the kinds and proportion of oils contained in the ſubſtance from which it has been obtained, and alſo the changes ſuffered by each of theſe oils from the degree of heat requiſite to render them empyreumatic. It will be only neceſſary here to obſerve, that all empyreumatic oils are acrid, and more or leſs ſoluble in ſpirit of wine; that the portion of theſe oils which riſes firſt in diſtillation is always the thinneſt; that by repeated diſtillations they may be rendered more and more thin and volatile; and that by a ſufficient repetition of theſe rectifications, they may almoſt be entirely deprived of their empyreumatic ſmell, ſo that only a pungent and penetrating ſmell ſhall remain; which ſeems to be common to all oils treated in this manner.

OILS, *improperly ſo called.* Many preparations were by the ancient chemiſts called oils, merely from their conſiſtence, although in other reſpects they were entirely different from oil. Theſe improper names ought to be aboliſhed, and they are accordingly falling into diſuſe by modern chemiſts. Nevertheleſs, as they are found in moſt chemical books in the time of Lemeri, and as many of them are ſtill frequently employed, we ſhall explain in a few words the chief of them.

OIL OF ANTIMONY. By this name the butter of antimony, and ſome other ſolutions of antimony by acids, are called. See ANTIMONY.

OIL OF ARSENIC. This is a combination of aerated marine acid with arſenic, and is made preciſely in the ſame manner as butter of antimony. Equal parts of arſenic and of corroſive ſublimate are mixed and diſtilled together, by which a liquor comes over ſimilar to the butter of antimony. This is a very powerful, but, at the ſame time, very dangerous cauſtic. This ſhews, that arſenic, like regulus of antimony, and ſeveral other metallic ſubſtances, is capable of decompoſing corroſive ſublimate, by ſeizing its acid. Accordingly, mercury is revived in this as in all the ſimilar operations. Theſe combinations reſemble the liquor of Libavius, which Adet has well explained. See TIN.

OIL OF MERCURY. When water is added to a ſolution of mercury in vitriolic acid to form the precipitate called turbith mineral, the acid thus diluted ſtill retains a portion of mercury diſſolved, which is properly a vitriol of mercury. This ſalt, which is cryſtallizable, may be obtained by evaporating the water which keeps it diſſolved. When expoſed to a moiſt air, it deliquiates into a liquor which Lemeri calls oil of mercury.

Lemeri

Lemeri alſo gives the name of oil of mercury to a ſolution of corroſive ſublimate in ſpirit of wine.

OIL OF LEAD. This is a ſolution of ſalt of lead in the eſſential oil of turpentine. This ſalt is to be put into a mattraſs, and upon it oil of turpentine is to be poured, till it covers the ſalt with a thickneſs of ſome fingers, and the whole is to be digeſted during ten or twelve hours. The liquor, ſays Lemeri, acquires a red colour. The author directs that the ſolution ſhould be concentrated, by diſtilling from it a part of the oil of turpentine; and he recommends it for its utility in cleanſing and cicatriſing ulcers, particularly thoſe which are putrid. This preparation, which Macquer ſays is certainly a powerful antiſeptic, muſt be very proper for theſe purpoſes.

Amongſt the oils improperly ſo called, this is one of thoſe to which the name of oil has been with leaſt impropriety given; for the baſis of it is actually oil, and that oil really keeps the lead in ſolution. Lemeri affirms, that we may thus entirely diſſolve a given quantity of oil of turpentine. This preparation, which has only been made for medicinal purpoſes, is intereſting alſo in chemiſtry, and deſerves a particular examination.

OIL OF SULPHUR. Some chemiſts have given this name to the concentrated acid of ſulphur. See SULPHUR.

OIL OF TARTAR BY DELIQUIUM. A name very frequently given to fixed alkaline ſalt reſolved into a liquor by the moiſture of the air, or even to a ſolution of that ſalt in water. This name is unſuitable, not only as the liquor is not of the nature of oil; but alſo becauſe a true oil of tartar is obtained by diſtillation of tartar. This liquor ought to be called alkali of tartar, or liquid vegetable alkali. See ALKALI FIXED VEGETABLE, and TARTAR.

OIL OF VENUS. Lemeri gives this name to the ſalt formed by the union of copper with the nitrous acid, when it is reſolved into a liquor by the moiſture of the air. It is a cauſtic and eſcharotic, like all other ſimilar combinations of metallic matters with any acids to which the name of oil was formerly given.

OIL OF VITRIOL. This name is very commonly, but improperly, given to concentrated vitriolic acid. See ACID VITRIOLIC.

OINTMENT. A compound of oily or unctuous matter, with powders or other ſubſtances, made of the conſiſtence of butter, for medical uſe.

OLEO-SACCHARUM. This name is given to a mixture of oil and ſugar, incorporated with each other, to render the oil more eaſily diffuſible in watery liquors. Sugar and all ſaccharine matters have in general a quality ſomewhat ſaponaceous, and conſequently are capable of producing this effect in ſome meaſure. Theſe oleo-ſaccharums are uſed in pharmacy, as a method of adminiſtering eſſential and other oils.

OLIBANUM. Thus, frankincenſe. A gum reſin, the product of the Juniperus Lycia Linn. brought from Turkey and the Eaſt Indies, uſually in drops or tears. The ancients diſtinguiſhed various ſorts of olibanum, as, 1. Olibanum, or thus maſculum, melax, melaſon, teſticulatum, or the pureſt, yellowiſh-white, round tears, which were frequently joined two together. 2. Thus fœmineum, or the yellower and more impure. 3. Thus mammoſum, or larger oblong roundiſh maſſes, ſomewhat reſembling a woman's breaſts. 4. Thus granuloſum, or ſmall granules. 5. Thus corticoſum, or ſuch maſſes as have pieces of the bark of the tree adhering. 6. Thus orobæum, or mica thuris; ſmall fragments, or particles broke off in carriage, &c. 7. Manna thuris, the finer duſt. 8. Thus indicum, or large maſſes, compoſed of different coloured tears, white and blackiſh, joined together.

At preſent only two kinds are diſtinguiſhed: the finer and purer tears are called olibanum in grains; the more impure fragments and maſſes, common olibanum, or olibanum in ſorts. The beſt is of a yellowiſh white colour, ſolid, hard, and brittle: when chewed for a little time, it renders the ſpittle white, and impreſſes an unpleaſant bitteriſh taſte; laid on burning coals, it yields an agreeable ſmell.

Out of an ounce of the pure tears, rectified ſpirit of wine diſſolved five drams two ſcruples and ſix grains: from the remainder, water took up two drams and five grains. Another ounce gave out to water at firſt three drams and a ſcruple; and afterwards to ſpirit, four drams thirty-three grains. The indiſſoluble matter, in the firſt operation, weighed twelve grains; in the other fourteen. Both the diſtilled ſpirit and water taſted pretty ſtrongly of the olibanum, but no ſeparable oil could be obtained. Olibanum is accounted corroborant, and ſuppoſed to be particularly ſerviceable in diſorders of the head, ſtomach, and breaſt. Its principal uſe is in plaſters, unguents, and in fumigations.

Olibanum is not, in any of its ſtates, what is called thus or frankincenſe in the ſhops. The common frankincenſe is a ſolid, brittle reſin, brought to us in little globes or maſſes, of a browniſh or yellowiſh colour on the outſide, internally whitiſh or variegated with whitiſh ſpecks; of a bitteriſh, acrid, not agreeable taſte, without any conſiderable ſmell. It is ſuppoſed to be the produce of the pine tree, which yields the terebinthina communis; and to concrete on the ſurface of the terebinthinate juice ſoon after it has iſſued from the plant.

OLIVES. The oil of this fruit is well known; it is obtained by expreſſion. The proceſs uſed in the South of France, as deſcribed by Chaptal, is very ſimple. The olive is cruſhed by a mill-ſtone, placed vertically, rolling upon an horizontal plane. The paſte thus formed is ſtrongly preſſed in a preſs; and the firſt oil which comes out is called virgin oil. The marc or pulp is then moiſtened with boiling water; the maſs is again preſſed; and the oil which floats upon the water carries with it part of the parenchyma of the fruit and a great part of the mucilage, from which it is difficultly cleared.

The difference in the kind of olive produces a difference in the oil; but the concurrent circumſtances likewiſe eſtabliſh other differences. If the olive be not ſufficiently ripe, the oil is bitter; if it be too ripe, the oil is thick and glutinous. The method of extracting the oil has a very great influence on its quality. If the oil-mills are not kept ſufficiently clean, the mill-ſtones, and all the utenſils, are impregnated with a rancid oil, which cannot but communicate its flavour to the new oil. In ſome countries it is uſual to lay the olives in heaps, and ſuffer them to ferment before the oil is drawn. By this management the oil is bad; and this proceſs can only be uſed for oil intended for the lamp or for the ſoap-boiler.

OLLARIS LAPIS. See LAPIS OLLARIS.

ONIONS. Neumann examined this root; he could not obtain any oil by diſtillation from twelve pounds of onions ſliced, and treated with water in the uſual manner. The water which came over contained all the active parts of the onions.

This root contains much aqueous moiſture. It loſt near four-fifths of its weight by drying, and the onions when half dry ſmelt like rue.

An ounce of the dry root yielded to Neumann with rectified ſpirit ſix drams of extract, and afterwards with water one dram eighteen grains. Another ounce, treated firſt with water, gave ſix drams thirty-five grains, and afterwards with ſpirit half a dram; the indiſſoluble reſiduum weighed in the firſt caſe two ſcruples ſixteen grains, in the latter eight grains more. The diſtilled ſpirit is

ſomewhat

ſomewhat impregnated with the oil of the onion, diſcoverable rather by its taſte than by its ſmell; the more ſubtile odorous parts having been diſſipated in the previous exſiccation. The ſpirituous extract taſtes ſtrongly of the onion: this is the ſtrongeſt preparation in point of taſte, and the diſtilled water in ſmell.—This root, beſides its culinary uſes, has been employed medicinally, as a reſolvent and diuretic, in cachexies, dropſies, nephritic caſes, &c.

ONYX. An agate generally opake, or but ſlightly tranſparent, conſiſting of differently coloured veins, parallel to each other, ſometimes in ſtraight and ſometimes in curved lines.

OPAL. Opalus, pædros Græcorum, the giraſole of the Italians.

It is the moſt beautiful of all the flint kind, owing to the changeable appearance of its colours by reflection and refraction, and muſt therefore be deſcribed under both theſe circumſtances.

Cronſtedt diſtinguiſhes two kinds of opal: the opal of Nonnius, or the ſangenen of the Indians. It loſes its colour and tranſparency in fire; and in other reſpects is affected by it as a quartz or flint. It fuſes with borax, though difficultly; and its ſpecific gravity is 1.900 and upwards.

This opal appears olive-coloured by reflection, and ſeems then to be opake; but when held againſt the light, is found tranſparent, and of a fine ruby red colour.

That opal is ſuppoſed to have been of this kind, which Pliny mentions in his Natural Hiſtory, book xxxvii. chap. 6, and which, he ſays, was in the Senator Nonnius's poſſeſſion, who rather choſe to ſuffer baniſhment than part with it to Anthony.

This ſtone was in Rome at that time valued at 20,000 ſeſterces. The ſtone here particularly deſcribed was found in the ruins of Alexandria: it is about the ſize of a hazle-nut, and was bought for a trifle of a French drogoman * named Roboly, and preſented to the French General Conſul Lironcourt, who afterwards offered it to ſale in ſeveral places for the ſum of 40,000 rix dollars. See Haſſelquiſt's Travels to the Eaſt, under the article opal.

There is, however, another of the ſame kind in Sweden, which by reflection appears rather brown; but by refraction it is red with violet veins. 2. The white opal; its ground is white of a glaſs-like complexion, from whence are thrown out green, yellow, purple, and blueiſh rays; but it is of a reddiſh or rather flame-colour, when held againſt the light.

Of this white opal there are three ſpecies. 1. Of many colours, or the oriental opal. 2. Of a milky colour, from Eibenſtock in Saxony. 3. Blueiſh and ſemi-tranſparent: this is not ſo much valued as thoſe which are more opake, becauſe it is eaſier to be imitated by art.

Not only this, but alſo ſome of the other kinds of opals have been well imitated by art, there being found compoſitions of glaſs, which ſhew very different colours by refraction from what appears by reflection. A curious ancient one of this kind is to be ſeen in the royal abbey of St. Denis, near Paris, which is green on the outſide, and ſhews a fine ruby colour when viewed againſt the light. Magellan makes mention of glaſs-paſtes, ſome made in London, by Edward Delaval, Eſq. F. R. S. and ſome others by Mr. More, Secretary to the Society of Arts, which appeared of a yellow brown, or other colour by reflection; but when held againſt the light, tranſmitted a fine blue, or a purple and red colour, like

* That is to ſay, interpreter and broker, in Turkey.

ſapphires, rubies, garnets, hyacinths, &c. Wallerius points out the proper ingredients to make theſe paſtes.

The principal effect of the opal, namely, that of reflecting one colour and tranſmitting another, is obſervable in a variety of coloured, or imperfectly tranſparent paſtes. It is common to all ſolids or fluids, on account of their imperfect tranſparency, but is not perceived in the greater number of them, becauſe a large maſs is in general required to intercept any conſiderable portion of the rays of light. Thus the ſea-water is blue by reflected light, and red by tranſmitted, as Dr. Halley obſerved in the diving bell. So likewiſe the common colour of the air by reflection is blue, and this blue colour tinges the images of diſtant mountains, in the clear elevated regions of Switzerland and elſewhere; but it is red by tranſmitted light, as is ſeen by the colour of the ſetting ſun, or moon, and that of the rays which fall on the clouds in the morning or evening, which differ according to the length of the portion of air through which the light paſſes. There is, however, another property of the opal, which has not been imitated by art, and affords the chatoyant effect, or variation of colour according to the poſition. This ſeems to ariſe from the foliated texture of the natural ſtone, which may be ſuppoſed to produce numerous extremely minute fiſſures, in certain determinate directions. The true opal may therefore be diſtinguiſhed by this property whenever it appears; or more generally by its hardneſs, for none of the artificial ſtones reſiſt the file.

The oculus mundi, or hydrophanes, is a curious ſpecies of the opal. See HYDROPHANES.

OPIUM. On wounding the heads or ſtalks of the poppy, a milky juice exudes, which exſiccated proves a fine kind of opium. In Natolia, Cilicia, Cappadocia, in the neighbourhood of Cairo, and in ſeveral other parts of the Turkiſh dominions, poppies are cultivated for this uſe in fields, as corn among us. The method of collecting the juice by inciſion is deſcribed by Kæmpfer, in his Amœnitates Exoticæ. This proceſs, however, is now but rarely practiſed, the conſumption of this drug being too great to be ſupplied by that method of collection. The beſt ſort of the officinal opium is the expreſſed juice of the heads, or of the heads and the upper part of the ſtalks, inſpiſſated by a gentle heat: this was formerly called meconium, in diſtinction from the true opium or juice which iſſues ſpontaneouſly. The inferior ſorts (for we find conſiderable differences in the quality of this drug) are ſaid to be prepared by boiling the plant in water, and evaporating the ſtrained decoction; but as no kind of our opium will totally diſſolve in water, the juice is moſt probably extracted by expreſſion. Neumann was informed by ſome Turks at Genoa and Leghorn, that in ſome places the heads, ſtalks, and leaves are committed to the preſs together, and that this juice inſpiſſated affords a very good opium.

On this head Dr. Lewis remarks, that the point has not, as yet, been fully determined. It is commonly ſuppoſed, that, whatever preparations the Turks may make from the poppy for their own uſe, the opium brought to us is really the milky juice collected from inciſions made in the heads, as deſcribed by Kæmpfer. It is certain, that an extract made by boiling the heads, or the heads and ſtalks in water, is much weaker than opium; but it appears alſo that the pure milky tears are conſiderably ſtronger.

The principles ſeparable from opium are, a reſin, gum, a minute portion of ſaline matter, water, and earth. The reſin is of two kinds; one more truly reſinous, of a ſolid conſiſtence, in its nature more fixed, and in its operation more

more ſluggiſh; the other ſofter and thinner, more volatile, and of much more ſpeedy and powerful activity. The ſaline matter is of the acidulous kind, analogous to the eſſential ſalts of other vegetables: its proportion is ſo ſmall, that it is not eaſily ſeparable in its proper form, though it has ſometimes happened, that actual cryſtals have concreted in a watery ſolution of opium. The reſin, the gum, and the ſalt, are very intimately combined together, inſomuch that all the three diſſolve almoſt equally in water and in ſpirit: it is probably to the ſaline principle, in this and other vegetables, that this intimacy of union is in great meaſure to be aſcribed.

Four ounces of opium, treated with highly rectified ſpirit of wine, yielded three ounces and four ſcruples of reſinous extract, five drams and a ſcruple of indiſſoluble impurities remaining. On taking four ounces more, and applying water at firſt, Neumann obtained two ounces five drams and one ſcruple of gummy extract; and, by digeſting the reſiduum in ſpirit of wine, three drams and one ſcruple of reſinous extract; the indiſſoluble part amounting here to ſeven drams and a ſcruple. In diſtillation, rectified ſpirit brought over little or nothing; but the diſtilled water was conſiderably impregnated with the particular ill ſmell of the opium.

The ſubtile ſoft kind of reſinous matter diſcovers itſelf in great meaſure in the bare watery ſolution of opium, generally riſing to the ſurface in form of a fat, unctuous, frothy ſubſtance. This is the ſtrongeſt and moſt active part of the opium; a few grains are ſufficient to kill a dog, who could bear a whole dram of crude opium. From a pound of opium we may collect two or three drams of this balſam-like ſubſtance; but we are not to imagine that this is the whole quantity which the opium contains: beſides what thus ſpontaneouſly ſeparates, a part remains combined with the reſt of the juice, and probably is the principle, or the direct ſeat of the principle, that gives activity to the whole.

As opium in ſubſtance is frequently found to be productive of unfavourable conſequences, different methods have been contrived for correcting or rendering it more univerſally ſafe. In this enquiry, every one has proceeded agreeably to the idea he had formed of the compoſition of opium, and endeavoured to counteract that principle in which he imagined its activity to conſiſt: hence the great variety of pretended correctors. Thoſe who aſcribed its power to a volatile alkaline ſalt, thought to mitigate it by acids, as ſpirit of vitriol, dulcified ſpirit of vitriol, citron juice; whilſt others, deducing its operation from an acid, uſed alkalies for the correctors. Some, preſuming it be of a cold nature, joined to it hot ſubſtances, as cinnamon, pepper, ginger, euphorbium, &c. Theſe kinds of additions accompany it in the ancient electuaries; and as moſt electuaries formerly received opium in their compoſition, opiatum became a general name for the form itſelf. Some, imagining opium to be impregnated with a narcotic ſulphur, endeavoured to diveſt it of that offending principle, by cutting it into thin ſlices, and gently roaſting it till it began to ſmell agreeably; others, afraid that this degree of torrefaction was inſufficient for the total diſſipation of the ſulphur, had recourſe to a ſtronger heat, and deſtroyed the opium and all its powers by burning. On what principles henbane ſeeds and other ſtupefactive bodies were joined to opium, it is hard to gueſs.

Neumann is perſuaded that the narcotic matter of opium is diffuſed throughout its whole ſubſtance; but that it reſides moſt copiouſly, and in the moſt eminent degree, in its finer, ſubtile, volatile parts; that theſe parts are capable of being

highly concentrated and exalted in their power by art. He aſſerts his knowledge of a certain preparation of opium, by which a whole chamber full of men may be preſently ſtupefied, and deprived of their ſenſes, and even of their lives alſo, without a ſingle grain being ſwallowed; that the narcotic matter cannot be ſeparated in any viſible form, without ſome admixture of the other parts; that opium cannot be totally freed from it, but by a deſtruction of the opium itſelf; that it operates nearly in the ſame manner as the vapour of burning charcoal, or the ſubtile exhalations from fermenting liquors.

To diſſipate a part of this ſubtile principle, and thus render the opium more mild and innocent, he recommends fermentation. But Dr. Lewis juſtifies the preſent practice by remarking, that it is a point of primary conſequence, in preparing a medicine of ſuch activity as opium, that it be always made of equal and certain ſtrength: fermentation, if it really weakens the power of the opium (as it probably does), muſt for that very reaſon render its ſtrength vague, and impoſſible to be aſcertained. It does not appear that the corrections of opium by fermentation, or other like proceſſes, do any thing more than what may be equally effected by a diminution of the doſe.

This judicious obſervation may alſo be applied to the very laborious proceſſes of Baumé and others, who do not ſeem to have ſucceeded in producing any ſubſtance more uniform in its operation than the crude opium.

OPOBALSAM. The moſt precious of the balſams is that commonly called Opobalſam, or Balm of Gilead, Opobalſamum, Balſamelæon, Balſamum verum album, Ægyptiacum, Judaicum, Syriacum, Gileadenſe, è Mecca, &c. This is the produce of certain trees, which grew formerly in the valley of Jericho, but after the conqueſt of the Holy Land by the Turks were removed to Grand Cairo, where the balſam plantation is ſaid to be now guarded by Janiſſaries, and the reſinous juice collected for the Sultan only.

The true balſam is of a pale yellowiſh colour, clear and tranſparent, about the conſiſtence of Venice turpentine, of a ſtrong, penetrating, agreeable, aromatic ſmell, and a ſlightly bitteriſh pungent taſte: by age it becomes yellower, browner, and thicker, loſing by degrees, like eſſential oils, ſome of its finer and more ſubtile parts. To ſpread, when dropt into water, all over the ſurface, and to form a fine, thin, rainbow-coloured cuticle, ſo tenacious that it may be taken up entire by the point of a needle, were formerly infallible criteria of the genuine opobalſam. Neumann however had obſerved, that other balſams, when of a certain degree of conſiſtence, exhibit theſe phænomena equally with the Egyptian.

This balſam, according to Proſper Alpinus, is obtained from a ſmall evergreen tree or ſhrub, about the ſize of the privet or cytiſus, with flexible branches, and a few leaves which reſemble thoſe of rue, or rather of the lentiſk-tree, ſet in pairs along a middle rib, with an odd one at the end. The branches are covered with two membranous thin barks, the outermoſt of a reddiſh-brown colour, the inner greeniſh; the woody part is white. The flowers are of a purpliſh-white colour, in ſhape like thoſe of acacia: the fruit is a ſmall reddiſh-black berry, containing yellow ſeeds.

The wood is ſaid to be inodorous, the bark fragrant and aromatic, the flowers highly odoriferous; the berries to be odorous, acrid and bitter, and to yield a yellow liquor of the appearance of honey. The branches and dry berries have been ſometimes brought into Europe, and kept in the ſhops for medicinal uſe,

the former under the name of xylobalſamum, the latter of carbobalſamum: whatever ſmell or taſte theſe ſubſtances may have when freſh, they have little of either as they come to us.

The precious balſam exudes in very ſmall quantities, from ſlight inciſions made in the bark. According to the author above mentioned, it is at firſt white, of a very ſtrong penetrating ſmell of the turpentine kind, but ſweeter and more fragrant, and of a bitter, acrid, aſtringent taſte. It looks in part turbid and thick, like the oil newly expreſſed from olives: afterwards it grows extremely thin, limpid and light; its colour changes to a greeniſh, then to a gold yellow, and by long keeping to that of honey: it now grows thick like turpentine, and loſes much of its fragrance.

Inferior ſorts of balſam are ſaid to be obtained by boiling the branches in water: when the liquor begins to boil, a thin oil ariſes to the ſurface, and on continuing the coction, a groſſer and a thicker one.

Mr. Geoffroy obſerves, that a ſolution of balſam of Gilead made in ſpirit of wine, turns milky on being poured into water, but does not depoſit any precipitate; and that this mixture is uſed in France as a coſmetic. He ſays, an equal quantity of oil of almonds is previouſly mixed with the balſam; but this ingredient can be of no uſe, as it totally ſeparates and falls to the bottom, whilſt the balſam diſſolves in the ſpirit.

OPODELDOC. A ſolution of ſoap in ardent ſpirit, with the addition of camphor and eſſential oils. It is uſed externally againſt rheumatic pains, ſprains, bruiſes, and other like complaints.

OPOPANAX. A concrete gummy reſinous juice, obtained from the roots of an umbelliferous plant (Panax paſtinacæ folio C. B. Paſtinaca opopanax Lin.) which grows ſpontaneouſly in the warmer countries, and bears the colds of this. The juice is brought from Turkey and the Eaſt Indies, ſometimes in round drops or tears, but more commonly in irregular lumps of a reddiſh-yellow colour on the outſide, with ſpecks of white, inwardly of a paler colour, and frequently variegated with large white pieces. It has a peculiar ſtrong ſmell, and a bitter, acrid, ſomewhat nauſeous taſte. Its virtues are thoſe of an attenuating and aperient medicine.

An ounce of opopanax, treated with rectified ſpirit of wine, gave two drams two ſcruples and ſix grains of reſinous extract, and afterwards with water, three drams of gum; two drams and a ſcruple remaining undiſſolved. Another ounce treated firſt with water, yielded three drams two ſcruples and ſix grains of gummy extract; and afterwards, with rectified ſpirit, one dram of reſin, the indiſſoluble part amounting to three drams and a ſcruple. Both the diſtilled water and ſpirit are impregnated with the flavour of the opopanax; but no actual oil can be ſeparated, at leaſt on diſtilling ſmall quantities of the juice.

ORANGE. The flowers of orange trees afford, by diſtillation, a very fragrant eſſential oil. From the rind of the fruit an eſſential oil may be obtained by expreſſion. The juice of the fruit contains an eſſential acid ſalt, mixed with much mucilage. This ſalt may be obtained in cryſtals, by diluting the juice, clarifying it with whites of eggs, and evaporation. The juice, not depurated from its mucilage, is apt to become mouldy; but by the above-mentioned method of depuration, a ſaline extract may be made, capable of being preſerved, and poſſeſſed of the ſame medicinal qualities as the juice, which is ſaid to be very powerful in the ſcurvy; or it may be advantageous to treat it in the ſame manner as lemon juice. See LEMONS.

The eſſential oil may be procured by preſſure of the peeling againſt an inclined glaſs. In Provence and in Italy the peeling is raſped; by which means the veſicles are torn, and the oil flows into the veſſel deſtined to receive it: this oil ſuffers the parenchyma which goes along with it to ſubſide, and becomes clear by ſtanding.

If a lump of ſugar be rubbed againſt theſe veſicles, it imbibes the volatile oil, and forms an oleo-ſaccharum, ſoluble in water, and very proper to give an aromatic flavour to certain liquids.

ORES are native ſubſtances, containing the metals in an altered ſtate, in all caſes either combined with ſome foreign ſubſtance, which deprives them of malleability and metallic brilliancy, or elſe ſo intimately mixed, that the particles of metal cannot be diſcerned. In all caſes wherein the metallic ſubſtance is clearly diſtinguiſhable, it is not called an ore, but a native metal.

The metal in moſt ores is in the ſtate of calx, viz. combined with vital air, according to the modern theory; and moreover deprived of phlogiſton, according to the ancient theory. When ores contain nothing but the calx of the metal with the addition of more or leſs fixed air, they are ſaid to be calciform; but when they are combined with other ſubſtances, they are ſaid to be mineralized. The mineralizers are either arſenic or ſulphur. Beſides the mineralizers there are various ſtony matters, which accompany ores in a certain peculiar way with regard to cryſtallization and appearance; which has occaſioned miners to conſider them as poſſeſſing an affinity to the ore. This ſtony accompaniment, of which a better notion may be formed by inſpection of ores than from any general deſcription, is called the matrix of the ore. The rocks that lie over the veins are called the roof; thoſe that lie under them the floor, and by ſome the hading. The matrix is almoſt always a finer ſpecies of ſtone than the ſurrounding rocks, though of the ſame genus. Even the rocks themſelves are of a finer grain as they approach the vein. There is no matrix peculiarly appropriated to any metal; it has only been remarked, that tin is generally found among ſtones of the ſiliceous genus, and lead very frequently among thoſe of the calcareous. See METALLURGY, and the ſeveral metals.

Ores therefore conſiſt *, 1. of metallic ſubſtances in a calcined or rather calciform ſtate; or, 2. of theſe ſubſtances combined with other matters, with which they are ſaid to be mineralized.

Calcined metallic ſubſtances, or calciform ores, are metallic ſubſtances deprived of phlogiſton, and in the ſtate of a calx, or metallic earth. See CALX. Such are all ferruginous ochres, which are calces of iron.

Mineralized ores are,—1. Simple, containing only one metallic ſubſtance; or, 2. Compound, containing two or more metallic ſubſtances.

Of the ſimple, and alſo of the compound ores, four kinds may be diſtinguiſhed:

1. Ores conſiſting of metallic ſubſtances, mineralized by ſulphur. Such is the lead-ore, called galena, compoſed of lead and ſulphur.

2. Ores conſiſting of metallic ſubſtances mineralized by arſenic. Such is the white pyrites, containing iron and arſenic.

3. Ores conſiſting of metallic ſubſtances, mineralized by ſulphur and by arſenic. Such is the red ſilver-ore, containing ſilver, arſenic, and ſulphur.

4. Ores conſiſting of metallic ſubſtances, mineralized by ſaline matters. Such are the native vitriols. Such alſo is probably the corneous ſilver ore, which,

* The remainder of this article is taken chiefly from Keir's Notes to Macquer's Dictionary.

according

according to Cronſtedt, is a luna cornea, or ſilver combined with marine acid. To this claſs alſo may be referred the ſilver mineralized by an alkaline ſubſtance, which Mr. Von Juſti ſays he has diſcovered.

Henckel, and after him Cramer and Macquer, affirm, that in mineralized ores, beſides the above-mentioned metallic and mineralizing ſubſtances, are alſo contained a metallic and an unmetallic earth. But Wallerius affirms, that the exiſtence of ſuch earths cannot be ſhewn, and that ſulphur is incapable of diſſolving unmetallic earths, and even the calces of all metallic ſubſtances, excepting thoſe of lead, biſmuth, and nickel.

Metals and metalliferous ores are found in various places.

I. They are found under water, in beds of rivers, lakes, and ſeas, and chiefly at the flexures of theſe: ſuch are the auriferous and ferruginous ſands, grains of native gold, ochres, and fragments of ores waſhed from mines.

II. They are found diſſolved in water: ſuch are the vitriolic waters containing iron, copper, or zinc.

III. They are found upon the ſurface of the earth. Such are many ochres; metalliferous ſtones, ſands, and clays; and lumps of ores. Mr. Gmelin ſays, that in the northern parts of Aſia ores are almoſt always found upon or near the ſurface of the ground.

IV. They are found under the ſurface of the earth. When the quantity of theſe collected in one place is conſiderable, it is called a mine.

Subterranean metals and ores are differently diſpoſed in different places.

1. Some are infixed in ſtones and earths, forming nodules or ſpots diverſely coloured.

2. Some are equally and uniformly diffuſed through the ſubſtance of earths and ſtones, to which they give colour, denſity, and other properties. Such are the greateſt part of thoſe earths, ſtones, ſands, clays, cryſtals, flints, gems, and fluors, which are coloured.

3. Some form ſtrata in mountains. Such are the ſlates containing pyrites, copper-ore, lead-ore, ſilver-ore, or blend. Theſe lie in the ſame direction as the ſtrata of ſtones, betwixt which they are placed; but they differ from the ordinary ſtrata in this circumſtance, that the thickneſs of different parts of the ſame metalliferous ſtratum is often very various; whereas the thickneſs of the ſtony ſtrata is known to be generally very uniform.

4. Fragments of ores are frequently found accumulated in certain ſubterranean cavities, in fiſſures of mountains, or interpoſed betwixt the ſtrata of the earth. Theſe are looſe, unconnected, frequently involved in clay, and not adherent to the contiguous rocks or ſtrata immediately, nor by intervention of ſpar or of quartz, as the ores found in veins are. Tin and iron mines are frequently of the kind here deſcribed.

5. Large entire maſſes of ores are ſometimes found in the ſtony ſtrata of mountains. Theſe are improperly called cumulated veins, becauſe their length relatively to their breadth and depth is not conſiderable.

6. Some inſtances are mentioned of entire mountains conſiſting of ore. Such is the mountain Taberg in Smoland; and ſuch are the mountains of Kerunavara and Luoſavara in Lapland, the former of which is 1400 perches long, and 100 perches broad. Theſe mountains conſiſt of iron ore.

7. Laſtly, and chiefly, metals and ores are found in oblong tracts, forming maſſes called veins, which lie in the ſtony ſtrata compoſing mountains.

The direction of veins greatly varies; ſome being ſtraight, and others curved.

Their poſition alſo reſpecting the horizon is very various; ſome being perpendicular, ſome horizontal, and the reſt being of the intermediate degrees of declivity.

The dimenſions, the quality, and the quantity of contents, and many other circumſtances of veins, are alſo very various. Miners diſtinguiſh the ſeveral kinds of veins by names expreſſive of their differences. Thus veins are ſaid to be deep; perpendicular; horizontal, or hanging, or dilated; rich; poor; morning, noon, evening, and night veins, by which their direction towards that point of the compaſs where the ſun is at any of theſe diviſions of the natural day, is ſignified.

Some parts of veins are conſiderably thicker than others. Small veins frequently branch out from large veins, and ſometimes theſe branches return into the trunk from which they iſſued. Theſe veins, from which many ſmaller veins depart, have been obſerved to be generally rich.

Veins are variouſly terminated: 1. by a gradual diminution, as if they had been compreſſed, while yet ſoft, by ſuperincumbent weight, or by ſplitting and dividing into ſeveral ſmaller veins: or, 2. they are terminated abruptly, together with their proper ſtrata in which they lie. This abrupt termination of veins and ſtrata is occaſioned by their being croſſed by new ſtrata running tranſverſely to the direction of the former; or by perpendicular fiſſures through the ſtrata; which fiſſures are frequently filled with alluvial matters, or with water, or are empty. Theſe perpendicular fiſſures ſeem to have been occaſioned by ſome rupture or derangement of the ſtratum through which the vein paſſes, by which one part of it has been raiſed or depreſſed, or removed aſide from the other, probably by earthquakes. Where the vein is terminated abruptly it does not ceaſe, but is only broken and disjoined; and is often recovered by ſearching in the analogous parts of the oppoſite ſide of the deranged ſtratum. A principal part of the art of miners conſiſts in diſcovering the modes of their derangements from external marks, that they may know where to ſearch for the disjoined vein.

The contents of veins are metals and metalliferous minerals, as the ſeveral kinds of ores, pyrites, blends, guhrs, vitriols; the ſeveral kinds of fluors, ſpars, quartz, horn-blend, in which the ores are generally imbedded, or inveloped, and which compoſe the matrix of the ore; ſtalactites; cryſtallizations of theſe metalliferous and ſtony ſubſtances, encruſting the ſmall cavities of the circumjacent rock; and laſtly, water, which flows or drops through crevices in that rock.

In a vein, ores are found ſometimes attached to the rock or ſtratum through which the vein runs, but more frequently to a matrix which adheres to the rock; and ſometimes both theſe kinds of adheſion occur in the ſame vein at different places. Frequently between the matrix and the rock a thin cruſt of ſtone, or of earth, is interpoſed, called by authors the fimbria of the ore.

The matrix, or the ſtone in which the ore lies inveloped, is of various kinds in different veins. And ſome kinds of ſtone ſeem better adapted than others to give reception to any ore, or to the ores of particular metals. Thus quartz, ſpar, fluors, and horn-blend, give reception to all ores and metals; but ſlates chiefly to copper and ſilver, and never to tin; calcareous and ſparry matrices, to lead, ſilver, and tin; and mica to iron.

Veins lie in ſtrata of different kinds of ſtone; but more frequently in ſome kinds of ſtone than in others. Thus, of the ſimple or uncompounded ſtones which compoſe ſtrata, the following are metalliferous: calcareous ſtones; ſlaty ſand

ſtone

ſtone *(eos fiſſilis arenoſus Wallerii)*; feltſpar *(ſpatum pyrimachum ſive ſcintillans)*; quartz, ſometimes jaſper, frequently ſlates, and chiefly micaceous or talky ſtones, and horn blend *(lapis corneus Wallerii*; *bolus indurata particulis ſquamoſis Cronſtedt.)* No veins have been found in gypſeous or ſiliceous ſtrata, though cherts and flints frequently contain metallic particles, and ſome inſtances have been obſerved of ores of ſilver and tin in alabaſter. Of compound ſtones, thoſe are ſaid to be chiefly metalliferous which conſiſt of particles of horn-blend. Veins have alſo been found in the red granite; but ſeldom, if ever, in any other granite, or in porphyry. In general, veins are more frequently found in ſoft, fiſſile, and friable ſtrata, than in thoſe which are compact and hard.

A vein ſometimes paſſes from one ſtratum into the inferior contiguous ſtratum. Sometimes even the veins of one ſtratum do ſo correſpond with thoſe of an inferior ſtratum, the contiguity of which with the former is interrupted by a maſs of different matter, through which the veins do not paſs, that they ſeem originally to have been continued from one ſtratum to the other. Thus, in the mines of Derbyſhire, where the veins lie in ſtrata of limeſtone, the contiguity of which ſtrata with each other is interrupted in ſome places by a blue marle or clay, and in other places by a compound ſtone called toadſtone, the veins of one ſtratum frequently correſpond with the veins of the inferior ſtratum of lime-ſtone; but are never continued through the interpoſed clay or toadſtone. But we muſt obſerve, that theſe interpoſed maſſes, the blue marle, clay, and toadſtone, have not the uniform thickneſs obſervable in regular ſtrata, but are (eſpecially the toadſtone) in ſome places a few feet in depth, and in others ſome hundreds of yards. The above diſpoſition ſeems to indicate, that theſe ſeveral ſtrata of limeſtone have been originally contiguous; that the veins now disjoined have been once continued; that theſe ſtrata of limeſtone have been afterwards ſeparated by ſome violent cauſe, probably by the ſame earthquakes which have in a ſingular manner ſhattered the ſtrata of this mountainous country; that the interſtices thus formed between the ſeparated ſtrata have been filled with ſuch matters as the waters could inſinuate, probably with the mixed comminuted ruins of ſhattered ſtrata; or with the lava of neighbouring volcanos, of which many veſtiges remain.

To the above hiſtorical ſketch of mines it may not be improper to add ſome conjectural remarks concerning their formation:

Thoſe ores which are found under water (I); upon the ſurface of the earth (III); in fiſſures of mountains and ſubterranean cavities, accumulated, but not adherent to the contiguous rocks (IV); ſeem from their looſe, unconnected, broken appearances to have been conveyed by alluvion.

All martial ochres have probably been ſeparated from vitriolic ferruginous waters (II), either ſpontaneouſly or by calcareous earth; and theſe waters ſeem to have acquired their metallic contents by diſſolving the vitriol which is produced by the ſpontaneous decompoſition of martial pyrites. The ochres of copper, zinc, and perhaps of ſeveral other metals, have probably been precipitated from vitriolic waters by ſome ſubſtance, as calcareous earth, more diſpoſed to combine with acids; and theſe vitriolic waters have probably been rendered metalliferous, by diſſolving the vitriols produced by a combuſtion of cupreous pyrites, and of the ore of zinc called blend; for theſe minerals are not, as martial pyrites is, ſuſceptible of decompoſition ſpontaneouſly, that is, by air and moiſture.

The metalliferous nodules and ſpots (IV. 1.), ſeem to have been infixed in ſtones while theſe were yet ſoft. Perhaps the metalliferous and lapideous particles

cles were at once diſſolved and ſuſpended in the ſame aqueous menſtruum, and during their concretion cryſtallized diſtinctly, as different ſalts do when diſſolved in the ſame fluid.

The earths and ſtones uniformly coloured by metals (IV. 2.) were alſo probably in a ſoft ſtate while they received thoſe tinges. The opake-coloured ſtones ſeem to have received their colour from metallic calces, mixed and diffuſed through the ſoft lapideous ſubſtance; and the tranſparent-coloured ſtones have probably received their colours from vitriolic ſalts, or from metallic particles diſſolved in the ſame water which ſoftened or liquefied the ſtony ſubſtance; which metallic ſalts and particles were ſo much diffuſed, that they could not be diſtinctly cryſtallized. That all ſtones have been once liquid and diſſolved in water, appears probable not only from their regular cryſtallized forms, but alſo from the ſolubility of ſome ſtone, as of gypſeous and calcareous earths in water; and from the water which we know is contained in the hardeſt marbles, as well as in alabaſters; to which water theſe ſtones owe the cryſtallization of their particles.

The veins called cumulated (IV. 5.), and the entire metalliferous mountains (IV. 6.), are believed by Wallerius to be analogous to the nodules (IV. 1.). Theſe metalliferous ſubſtances ſeem to have been originally formed or concreted in the places where they are found.

The metalliferous ſtrata (IV. 3.) have probably been inſinuated between the lapideous ſtrata, after the ſeparation of theſe from each other by ſome violent cauſe; in the ſame manner in which it was ſuppoſed that the clay and toadſtone have been inſinuated betwixt the ſeveral ſtrata of limeſtone in Derbyſhire. The matters thus inſinuated may have been either fluid, which would afterwards cryſtallize, and form entire regular maſſes; or they may have been the ruins of ſhattered ſtrata, and veins brought by waters, and there depoſited: in which caſe they will appear broken and irregular. The metalliferous ſtrata, though frequently confounded with the horizontal or dilated veins, may be diſtinguiſhed, according to Wallerius, from theſe by the following properties:—1. They are generally thinner and much broader than the veins called dilated. 2. They are ſeldom found at a greater depth than 100 perches, and generally in the neighbourhood of veins, from which they probably have received their contents. 3. From their want of the thin incruſtations called fimbriæ, which, as has been obſerved, are frequently interpoſed betwixt the rock and the ore, or its matrix; and from their want of the other properties of veins.

But in veins properly ſo called the ſtrongeſt marks exiſt of ores having been there concreted, and not carried thither and depoſited in their preſent ſtate. Their regular, unbroken appearance, their adheſion to the contiguous rock, either immediately or by intervention of a matrix, the regular appearance of this matrix inveloping the ore, the frequent cryſtallization of the ore, and of the other contents of the vein, indicate that ores, as well as the other ſolid contents, have been there concreted from a fluid to a ſolid ſtate.

Moſt authors believe, that veins, and the perpendicular clefts in the ſtony ſtrata of mountains, called fiſſures, have been produced by the ſame cauſe; or, rather, they conſider veins only as fiſſures filled with metalliferous matters. They further believe, that fiſſures have been occaſioned by the exſiccation of ſtrata, while theſe were paſſing from a fluid to a ſolid ſtate. Wallerius thinks, that fiſſures have been formed from exſiccation; but that veins were channels made through the ſtrata, while yet ſoft and fluid, by water, or by the more fluid parts of the ſtrata, penetrating and forcing a paſſage through the more ſolid

parts.

parts. He thinks, that theſe fluid parts conveyed thither their metalliferous and ſtony contents, which were then coagulated or concreted. He ſupports his opinion by obſerving, that all the veins of the ſame ſtratum generally run parallel to each other; that they frequently bend in their courſe; that the ſame vein is ſometimes contracted and ſometimes dilated; that veins are frequently terminated by being ſplit or divided into inferior veins; that veins are frequently wider at bottom than at top, whereas fiſſures are always wideſt at top, and are very narrow below: all which appearances, he thinks, could not have been produced by exſiccation. From theſe reaſons, fiſſures appear to have had a different, and from the disjunction and rupture of veins croſſed by fiſſures, they ſeem to have had a later, origin than veins. Whether fiſſures could have been produced by the very gradual exſiccation of theſe large maſſes, or ſtrongly coherent matter; or whether they have been produced by the ſame violent cauſes, namely, earthquakes, by which the ſtrata in which fiſſures are generally found have been broken and deranged, and by which metalliferous mountains themſelves have been formed, or their ſtrata raiſed above their original level, as ſome others have with great probability conjectured, cannot with certainty be determined.

Veins are ſeldom, if ever, found but in mountains; the reaſon of which may not improbably be, that in metalliferous mountains we have acceſs to the more ancient ſtrata of the earth, which in plains are covered with ſo many depoſited, alluvial, and other later ſtrata, that we can ſeldom if ever reach the former. That theſe mountains conſiſt of ſtrata which have been originally lower than the upper ſtrata of adjacent plains, appears from an obſervation which has been made, that the ſtrata of mountainous countries dip with more or leſs declivity as they approach the plains, till they gradully ſink under the ſeveral ſtrata of thoſe plains, and are at laſt immerſed beyond the reach of miners. This leading fact in the natural hiſtory of the earth has been obſerved by a ſagacious philoſopher, Mr. Mitchell, in his Conjectures concerning Earthquakes, &c. Philoſ. Tranſ. 1760.

That the inferior ſtrata of the earth contain large quantities of pyritous, ſulphureous, and metalliferous matters, appears, 1. From the ſubterranean fires in thoſe inferior ſtrata, which produce volcanos, and probably earthquakes (as Mr. Mitchell ingeniouſly conjectures). 2. From the obſervation, that all kinds of mountains are not equally metalliferous; but that veins, eſpecially, are only found in thoſe mountains, which, being compoſed of very ancient ſtrata, are called primæval, which form the chains and extenſive ridges on the ſurface of the earth, which direct the courſe of the waters, and which conſiſt of certain ſtrata, the thickneſs of each of which, its genuine qualities, and its poſition relatively to the other ſtrata, are, in different parts of the chain of mountains where that ſtratum is found, nearly uniform and alike, notwithſtanding that the numbers, and the inclinations of the ſtrata compoſing contiguous mountains, or even different parts of the ſame mountain, are often very various; and therefore that veins are ſeldom, if ever, found in the mountains called by authors diluvial and temporary, which are ſingle, or detached, which conſiſt not of ſtrata uniformly diſpoſed, but of alluvial maſſes, in which fragments of ores may be ſometimes, but veins never, found. Nevertheleſs, ſingle, and ſeemingly detached, mountains in ſmall iſlands have ſometimes been found to be metalliferous. But we muſt obſerve, that theſe mountains conſiſt of uniform ſtrata; that iſlands themſelves, eſpecially ſmall iſlands, may be conſidered as eminent parts of ſubmarine ranges of mountains; and that the mountains of ſuch iſlands may be conſidered as apices or tops only of inferior mountains.

Thoſe mountains are ſaid to be moſt metalliferous which have a gentle aſcent, a moderate height, and a broad baſis, the ſtrata of which are nearly horizontal, and not much broken and disjoined. In theſe mountains, at leaſt, the veins are leſs interrupted, more extended, and conſequently more valuable to miners than the veins in lofty, ſcraggy, irregular, and ſhattered mountains.

Authors diſpute concerning the time in which ores have been formed, ſome referring it to the creation of the world, or to the firſt ſubſequent ages; and others believing, that they have been gradually from all times, and are now daily, forming. From the accretion of ores and of their matrices to their proper rocks, and from the inſertion of metalliferous nodules and ſtriæ in the hardeſt ſtones, it ſeems moſt probable, that the matter of thoſe veins and nodules is nearly coeval with the rocks and ſtones in which they are enveloped. Nevertheleſs, it cannot be doubted but that ſmall quantities, at leaſt, of ores are ſtill daily formed in veins, fiſſures, and other ſubterranean cavities. Several well atteſted inſtances confirming this opinion are adduced by authors: Cronſtedt mentions an incruſtation of ſilver ore that was found adhering to a thin coat of lamp-black, or of ſoot, with which the ſmoke of a torch had ſoiled a rock in a mine at Koningſberg, in Norway; and that this incruſtation of ſilver ore has been formed by a metalliferous water paſſing over the rock. Lehman affirms, that he poſſeſſes ſome ſilver ore attached to the ſtep of a ladder, found in a mine in the Hartz, which had been abandoned two hundred years ago; and that ſeveral ſteps of ladders ſimimilarly incruſted had been found. Many other inſtances are mentioned by authors, of galena, pyrites, ſilver ores, and other metalliferous ſubſtances having been found adhering to wood, to foſſil-coal, to ſtalactitical incruſtations, to oyſter ſhells, and other recent ſubſtances. From theſe, and from ſimilar inſtances, it ſeems probable, that not only ochres and fragments of ores may, with other alluvial matters, be now daily depoſited, but alſo that ſmall quantities of mineraliſed ores are recently formed; although many hiſtories mentioned by Becker, Barba, Henckel, and other authors, of the entire renovation of exhauſted veins, and eſpecially thoſe of the growth and vegetation of metals and of ores, appear to be at leaſt doubtful.

Various opinions have been publiſhed concerning the formation of mineralized ores. According to ſome, theſe ores were formed by congelation of the fluid maſſes found in mines, called gurhs. Other authors believe, that ores have been formed by the condenſation of certain mineral, metallic, ſulphureous, and arſenical vapours, with which they ſuppoſe that mines abound. Some have even affirmed, that they have ſeen this vapour condenſe, and become in a few days changed into gold, ſilver, and other metallic matters. It has been above obſerved, that from ſeveral appearances which occur in veins, there is great reaſon to believe, that ores have not been carried thither and depoſited in their preſent ſtate, but have been there concreted and cryſtallized, that is, changed from a fluid to a ſolid ſtate. But the fluidity of the metalliferous matters at the time of their entrance into veins may have been occaſioned either by their having been diſſolved in water, if they were capable of ſuch ſolution, or by their having been raiſed in form of vapour by ſubterranean fires. For the diſpoſition to cryſtallize is acquired by every homogeneous ſubſtance that is fluid, whether it has received its fluidity by being melted by fire, or by being diſſolved in a liquid menſtruum, or by being reduced to the ſtate of vapour. Thus, cryſtals of ſulphur have been obſerved to be daily formed by the ſulphureous vapours which exhale in the neighbourhood of volcanoes. The volatility of the two mineralizing ſubſtances, ſulphur and arſenic,

arſenic, and the power which volatile bodies poſſeſs of elevating a certain portion of any fixed matter which happens to be united with them, render it probable, that the greateſt part at leaſt of mineralized ores have been formed of vapours exhaled from ſubterranean fires, through the cracks in the intervening ſtrata, occaſioned by thoſe earthquakes which have, in a ſingular manner, broken and deranged the ſtrata of metalliferous countries, and which, as has been above remarked, have been probably occaſioned by, at leaſt have certainly been always accompanied with, ſubterraneous fire.

ORES OF ANTIMONY. Antimony has been found in the native ſtate of a ſilver colour, and its texture compoſed of moderately large, ſhining plates, reſembling the regulus of antimony of commerce. It has the ſame habitudes in acids, and aqua regia more particularly diſſolves it very well. The ſolution does not loſe its tranſparency in the cold. Alkalis throw down a white precipitate. The Pruſſian alkali affords a green precipitate with ſmall blue ſpecks, which ſhews the preſence of iron. In the fire, native antimony melts and is volatilized in white flowers; but a ſubſtance of a fat and oily appearance is formed round the fuſed metal in much greater abundance than with the pure regulus. Mongez aſſerts, that this is the calx converted into glaſs of antimony. On the firſt impreſſion of the heat, a ſlight ſmell of arſenic is emitted, which quickly diſappears. M. Sage, in fact, found ſixteen per cent. of arſenic in the native regulus from Allemont, in Dauphiny. If this native ore be fuſed in a crucible without any reducing matter, a very neat button is obtained, ſuſceptible of cryſtallization, more brilliant and clear in its fracture, which exhibits larger plates than before.

The appearances of this native metal, before the blow-pipe, correſpond with thoſe obſerved in the larger proceſs. It evaporates in ſmoke with a ſmell of garlic; a white powder is depoſited on the charcoal, of which the arſenical portion becomes black and fixed, on application of the interior cone of the flame. The fluxes acquire a faint hyacinth tinge.

Mongez likewiſe acquaints us with a native calx of antimony, obſerved by him, upon a piece of the native regulus from Chalangez, in Dauphiny. It is uſually cryſtallized in very white, ſlender needles, in ſome portions confuſed with the plates of the antimony, and in others, radiated from a centre exactly like the cryſtallized zeolite. Theſe did not contain arſenic.

The moſt common and abundant ore of antimony is known in commerce ſimply by the name of antimony, and conſiſts of the ore in combination with ſulphur. It is compoſed of filaments, or needles, adherent to each other, either parallel, or divergent from a centre. Theſe are friable, brilliant, uſually of a ſhining metallic blueiſh-gray colour; ſometimes of a lively chatoyant appearance, according to Mongez; but I think on recollection, not having a ſpecimen of the ſort before me, that theſe colours, though variegated, do not change their poſition with the eye of the obſerver, or at leaſt exhibit none of that internal appearance denoted by the word chatoyant. They ſhould therefore rather be called irideſcent.

When this ore of antimony poſſeſſes a leſs determined internal ſtructure, it may be miſtaken for the ſmall grained lead ore, or white ſilver ore, or iron glemmer; but it may be diſtinguiſhed by the ſmell of ſulphur it exhibits when broken or rubbed, and ſtill more effectually by its fuſibility, which is ſuch that it runs in the flame of a candle. The ſulphur may be eaſily ſeparated, and its quantity aſcertained by aqua regia, which diſſolves the metal, and leaves the

ſulphur floating at the ſurface. The aqua regia, according to Kirwan, ought to conſiſt of one part nitrous, and four marine acid.

The ſpecific gravity of this ore of antimony is for the moſt part from 4,000 to 4,200, and after fuſion from 4,700 to 5,000. There are ſeveral varieties: 1. The gray ſtriated ore of antimony. 2. Plumous ore of antimony. This has the form of ſmall, ſilky, gray or blueiſh filaments, almoſt always effloreſcent. There are ſome ſpecimens of a deep red, and of a pulverulent reddiſh colour, in priſms effloreſcent upon the gray ore. The ore from Tuſcany is of this kind. M. Sage conſiders the red plumous ore of antimony as a native golden ſulphur, and the pulverulent reddiſh ore as a native kermes mineral. 3. The ſolid gray ore of antimony. This is a uniform maſs of the colour of poliſhed iron or lead, very brittle, and its fracture exhibits ſmall brilliant faſcets, and ſometimes filaments. It melts and is volatilized by the flame of a candle.

The ſulphureous ore of antimony urged by the flame of the blow-pipe is liquefied, flows on the charcoal, ſoaks into it, and at length entirely diſappears, except a portion of flowers, which are depoſited circularly. One hundred parts of the ore contain twenty-four parts of the regulus ſlightly calcined, and twenty-ſix of ſulphur. For the analyſis in the dry way, ſee ANTIMONY.

The red ore of antimony has the ſame texture with the common ſulphureous ore, but its fibres are not ſo coarſe. Almoſt all antimonial ores contain arſenic, but the proportion in this is more abundant. Wallerius diſtinguiſhes three varieties found in Hungary and Saxony, viz. the red, the violet, and the pale red.

ORES OF ARSENIC. Arſenic is found native in Saxony, Bohemia, Hungary, and elſewhere, but particularly at St. Marie aux Mines in Alſatia. It is often found of no determinate figure, friable, and pulverulent; but ſometimes compact, divided into thick, convex plates, with a needle-formed or micaceous ſurface. It is of a lead colour when freſh broken, and may be cut with a knife, like compact black lead, but ſoon blackens by expoſure to the air. In hardneſs it ſeems to exceed copper, but is brittle like antimony. It burns with a ſmall flame, and goes off in ſmoke. Cronſtedt ſays nothing of the reſidue, but Bergman remarks that he never found native arſenic without iron.

Native arſenic before the blow-pipe takes fire emits a white ſmoke, covers the charcoal with flowers of arſenic, which quickly become black. A ſtrong ſmell of garlic is emitted. If the portion of iron it contains be conſiderable, it remains on the coal; if not, it diſappears. It communicates a yellowiſh colour to the flux, which diſappears in proportion as the arſenic is volatilized.

Calciform arſenic is in general ſcarce. It is either in a looſe or powdery form, or elſe in white ſemi-tranſparent cryſtals. Like the artificial calx, it is volatilized by heat, emitting a ſmell of garlic, and poſſeſſes the ſame ſolubility in water. See ARSENIC. It does not detonate with nitre, though an effervescence ariſes. It is ſcarcely ſoluble in the vitriolic acid, ſomething more in the marine, but moſt perfectly in the diluted nitrous acid. Before the blow-pipe, it evaporates in white flowers, which cover the charcoal. The peculiar ſmell of garlic appears to be ſufficiently diſtinctive of this ſemi-metal; but Mongez obſerves, as the characteriſtic marks of the reſpective flowers of arſenic, antimony, and zinc, that the firſt, when diſtributed upon the charcoal, become ſuddenly black if touched with the interior part of the flame, the ſecond remain white, and the third become yellow.

The combinations of arſenic with ſulphur are either *orpiment* or *realgar*. Theſe are alſo produced by art. See the words. Native orpiment is of a

yellow colour, inclining to red in ſome ſpecimens, and green in others. It is frequently mixed with yellow mica and ſpar, which cauſe it to appear as if compounded of faſcets of greater or leſs magnitude. In the fire its colour becomes obſcure, a white blueiſh flame appears, with a conſiderable mixed ſmell of garlic and ſulphur. By an open fire it is almoſt entirely volatilized, and leaves only a greeniſh earthy reſidue; but in a cloſe veſſel it melts, and in cooling becomes the reddiſh maſs called realgar. It is eaſily diſtinguiſhed from artificial orpiment, becauſe its figure is almoſt always that of ſmall, ſilky, light cryſtals, or granulated.

Native realgar has got a more lively colour, and poſſeſſes every degree of tranſparency, from that of the clear red cryſtals, called the ruby of arſenic, which is compact and hard, to that of perfect opacity. Its habitudes before the blow-pipe are the ſame as thoſe of orpiment.

Bergman's method of analyſing theſe ores conſiſts in digeſting them in marine acid, adding the nitrous by degrees, to help the ſolution. The ſulphur will be found on the filtre, and the arſenic will remain in the ſolution, from which it may be precipitated in its metallic form, by zinc, adding ſpirit of wine to the ſolution.

Arſenical ores, containing the other metals, are in general diſtinguiſhed by their reſpective denominations. The arſenical pyrites, or marcaſite, contains ſulphur and iron. It is of a gray aſh colour, inclining to blue, either ſolid or compoſed of ſmall brilliant particles. It tarniſhes in the air, gives fire with ſteel, and emits a ſmell of garlic. Sometimes it effervеſces with the nitrous acid, which partly diſſolves it. In the fire it is volatilized, and forms a true realgar, which diſtinguiſhes it from miſpickel, which contains iron and acid without ſulphur, and might eaſily be confounded with it. See MISPICKEL, alſo ARSENIC.

ORES OF BISMUTH. Biſmuth is the moſt common of all native metallic ſubſtances. It is generally found either in cubes or octagons, or of a dendritical form, or elſe in thin lamina inveſting the ores of other metals, particularly thoſe of cobalt. As it is very fuſible, it may eaſily be extracted by expoſing the minerals which contain it to a gentle heat. It then exſudes in ſmall white globules, the more readily in proportion to its purity. It effervеſces with nitrous acid, forming a ſolution at firſt milky, but which afterwards becomes clear. It is ſaid to be ſometimes alloyed with ſilver, in which caſe, a ſeparation may eaſily be made, by adding water to the nitrous ſolution, which throws down the biſmuth in the form of magiſtery.

Calciform biſmuth is found of a whitiſh or greeniſh-yellow colour, frequently upon the other ores of biſmuth, probably formed by decompoſition. It is then called flowers of biſmuth, and may be diſtinguiſhed from the flowers of cobalt by the red colour of the latter; for the flowers of biſmuth are never red, nor become ſo. This calx is readily diſſolved in nitrous acid, and a biſmuth may be precipitated by water.

The calx of biſmuth is reducible on the charcoal by the blow-pipe, and melts in the ſpoon. With microcoſmic ſalt it affords a globule of a dull yellow colour, which becomes paler and rather more opake by cooling. With borax, a maſs is obtained in the ſpoon which is gray upon the charcoal, and not eaſily cleared of ſmall bubbles. This glaſs fumes when kept in a ſtate of fuſion, and forms a circle of a greeniſh-yellow colour around it, produced by the volatilization of part of the biſmuth.

Biſmuth is mineralized by ſulphur. It reſembles galena or potters' lead ore in colour and appearance, is brittle, eaſily cut with a knife, and does not effervеſce with

with acids, though ſoluble in aqua fortis. The ſolution is clear, and ſometimes greeniſh. It is ſaid to contain alſo cobalt and arſenic, but Mongez denies the latter. It is very fuſible, and the ſulphur moſtly ſeparates in ſcorification. There are two varieties; the one teſſular like galena, from Baſtanes in Sweden, and Schneeberg in Saxony, which is very ſcarce; the other ſtriated, compoſed of ſcales or ſmall needles, like the ſulphureous ore of antimony, but does not ſoil the fingers. It comes from Schneeberg and John-Gorgenſtadt in Saxony.

Before the blow-pipe this ore ſpeedily melts, and affords a blue flame with a ſmell of ſulphur, but the perfect reduction is rather long and difficult. Bergman adviſes to precipitate the biſmuth with a ſmall quantity of cobalt, which penetrates the globule by virtue of the ſulphur. The maſs then ſwells up, and produces a ſcoria divided into very evident compartments. This ſcoria, kept a longer time in the fire, emits globules of biſmuth.

Biſmuth is alſo found mineralized with ſulphur and iron. This ore is compoſed of ſmall, thick, uniform ſcales, of a gray-yellowiſh colour when recently broken, but more yellow where it has ſuffered expoſure to the air. This ſpecies is more difficult to reduce than the preceding, on account of the iron it contains.

Wallerius, Sage, and Romé de Liſle, mention an ore of biſmuth mineralized with ſulphur and arſenic, which is of a ſhining appearance, of a whitiſh-yellow, or aſh colour, compoſed of ſcales, in general ſmall, hard, ſometimes giving fire with a ſteel, not effervеſcent with nitrous acid, though partly ſoluble. Mongez is diſpoſed to think it merely the ſulphureous ore of biſmuth, already mentioned, but obſerves that the preſence of arſenic cannot but ſhew itſelf by its peculiar ſmell when heated. See BISMUTH.

ORES OF COBALT. Cobalt has not been found in a ſtate of native purity, but the combination of this ſemi-metal with arſenic and iron in the metallic form uſually paſſes for ſuch. The quantity of iron is ſmall. This ore is ſolid, hard, ponderous, of a gray colour, more or leſs obſcure, ſometimes inclining to red. Its fracture is granulated, not unlike ſome kinds of ſteel. It commonly gives fire with the ſteel, and emits a ſtrong ſmell of garlic. In the fire it becomes black. Nitrous acid diſſolves it with effervеſcence, which affords a ſympathetic ink by the addition of marine acid. There are two characters which readily diſtinguiſh this mineral from the white and gray ores of arſenic. 1. It forms a ſympathetic ink with aqua regia; and 2. It affords a blue glaſs with borax, whereas that of the ore of arſenic is black. There are two varieties, the one ſolid and compact, the other granulated and eaſily broken, beſides that its colour is of a reddiſh-white, and ſometimes a little hepatic.

Before the blow-pipe this ore firſt emits a ſtrong ſmell of garlic, then becomes black, and melts into a ſmall globule of the regulus. It gives a blue colour to the fluxes.

The calciform cobalt is commonly found in the earth mixed with arſenic, iron, or copper; but whether mechanically, or more intimately combined, is doubted by Bergman. It is uſually of a gray-black, but ſometimes ſo black that it might be taken for ſoot. It ſoils the fingers, and is almoſt always friable and pulverulent. On breaking a compact ſpecimen, roſe-coloured ſpots may frequently be obſerved, reſembling the flowers of cobalt. It is ſeldom without a mixture of a ſmall portion of calx of iron. When ſolid, it ſometimes has the reſemblance and form of a vitreous ſcoria, whence ſome mineralogiſts have called it the vitreous ore of cobalt or ſlag. Theſe are free from ſulphur and arſenic. Cronſtedt compares the friable ore, or cobalt ore, to the artificial zaffre. Mongez ſays it contains clay.

Before the blow-pipe, as the black calx of cobalt is always mixed with a ſmall portion of the red calx which is arſenical, it emits a ſlight ſmell of garlic. The reduction is very difficult. But it diſſolves in borax, gives it a blue colour, and is partly reduced in a ſmall metallic globule, which occupies the lower part of the flux.

ORES OF COPPER. Copper is not, according to the opinion of Bergman, found native without a mixture of gold, ſilver, or iron. Some ſpecimens, however, nearly reſemble the refined copper in colour, malleability, and ductility. Others, inſtead of poſſeſſing the reddiſh colour, are rather of a yellow or brown colour, with green or blue ſpots of ruſt. It is found in two different forms: 1. Solid native copper, which is either cryſtallized or in grains, or thin leaves, threads or dendrites adherent to different matrixes, ſuch as calcareous ſtones, ſpars, quartz, petro-ſilex, jaſper, ſchiſtus. There are few copper ores, according to Mongez, which do not contain ſome of theſe varieties. 2. Native copper in the form of ſmall or imperfectly-coherent grains. This copper appears to have been depoſited from vitriolic waters by means of iron, for which reaſon it is called cement copper.

Kirwan directs the humid aſſay of native copper by nitrous acid. The gold, if it contains any, remains undiſſolved in the form of a black powder, which may be taken up and examined by aqua regia. The ſilver may be precipitated from the nitrous ſolution by marine acid, or better by copper, and the iron falls down in the form of an inſoluble calx by ſufficient ebullition with water.

The calciform copper ores are either of a red, blue, or green colour.

The red copper ore is rather ſcarce. In ſome ſpecimens it is of a beautiful red, or of a brown-reddiſh liver colour, whence it has obtained the name of hepatic ore. When in a looſe form it is called copper ore; but generally it is moderately hard, though brittle, ſometimes cryſtallized and tranſparent, either in a capillary form, or in cubes, priſms, or pyramids. Mongez ſays, that the moſt common form is that of fine grains reſembling the flowers of cinnabar. It is eaſily diſtinguiſhed by its brightneſs and ruddy colour, which approaches that of copper. It effervesces with acids, which diſſolve it as well as the other calciform ores of copper. Another common character of theſe ores is, that they blacken in a moderate heat, to which may be added, the property of affording a blue colour with the volatile alkali.

According to Fontana, quoted by Kirwan, a hundred parts of this ore contain ſeventy-three of copper, twenty-ſix of fixed air, and one of water. Bergman alſo found it to contain fixed air. The brown or hepatic ore contains a variable proportion of iron or pyrites, and ſometimes ſulphurated copper, and hence affords from 20 to 50 per cent. of copper. It is often irideſcent.

The blue calciform copper ore moſt frequently appears in a looſe form, though ſometimes indurated and even cryſtallized, but it is then mixed with quartz. It frequently lines the internal cavities of different matrixes. When the blue colour is very lively, it is called azure of copper, when paler, mountain blue, and when abounding with earthy matter, blue chryſocolla. It muſt be confeſſed however, that theſe terms are by no means accurately applied, but taken for the moſt part indiſcriminately. Morveau, in Memoirs of Dijon, has inferred from experiment, that the calces of copper are determined to a blue rather than to a green by a nearer approach to the metallic ſtate; but on this head ſee VERDITER.

The green copper ore is diſtinguiſhed by the names mountain green, or green chryſocolla. It is found in two ſtates, either earthy and friable, of a more or leſs deep

deep green, or elſe ſolid and cryſtallized. The moſt beautiful ſpecimen is the ſilky copper ore, ſo called becauſe its texture exhibits long ſhining filaments.

The ſolid green ore is uſually called malachite. See MOUNTAIN GREEN, MOUNTAIN BLUE, and MALACHITE.

Analogous to the calciform copper ores, are the lapis armenus, and the turquoiſe, the former of which is a blue ſtone, that does not admit of a poliſh, and conſiſts of calcareous earth or gypſum, penetrated with the blue calx of copper; hence it ſometimes effervеſces with acids, and ſometimes not; but never gives fire with ſteel. It loſes its colour when well heated in the fire. This ſtone is very different from the lapis lazuli, ſince this laſt contains no copper. See LAPIS LAZULI.

The turquoiſe appears to be the tooth of an animal, penetrated with the blue calx of copper. It loſes its colour when over-heated. It is opake, of a lamellar texture, and ſuſceptible of a fine poliſh.

Its ſpecific gravity is from 2,5 to 2,908. Some are of a deep blue, ſome of a whitiſh blue, but become of a deeper when heated. Theſe ſtones are found in Perſia and in Turkey, from whence they received their name. But they are alſo found in Lower Languedoc, in France, near the village Simere, where theſe ſtones, when dug out from the mine, reſemble different bones, teeth, &c. of various ſizes; and are whitiſh, grey, or yellowiſh. They receive the blue colour on being ſlowly heated to a high degree; but if the fire be long continued afterwards, the colour is irrecoverably loſt.

Jewellers divide this kind of ſtones, or rather bony ſubſtances, according to their fanciful method, into oriental and occidental turquoiſes (ſee ORIENTAL); ranging the hardeſt and the fineſt coloured under the firſt epithet; and the ſofteſt, or of an inferior colour, under the ſecond denomination. But, although experience ſhews the fallacy of ſuch diſtinctions in a great many inſtances, the old cuſtom continues nevertheleſs to prevail.

According to Kirwan, the blue coppery tincture of the turquoiſes may be extracted from them by diſtilled vinegar: and Reaumur aſſerts, that nitrous acid will not diſſolve the Perſian turquoiſes, though it will thoſe of France; which, if true, indicates a real difference between them.

Bergman from Werner mentions a copper ore, conſiſting of that metal mineralized by fixed air, and combined with clay. This is moſt commonly ſuperficial in ſmall cryſtals of a beautiful green, or in ſmall ſcales, and was formerly conſidered as a variety of mica or talc. Nitrous acid diſſolves it very well, and the ſolution takes a green colour. The copper may be precipitated in the uſual manner. The blow-pipe does not fuſe this ore, if the flame be directed againſt its flat ſurface; but if the edge be attacked, it ſpeedily melts into a black ſcoria. With borax it affords a brown yellow glaſs, and with microcoſmic ſalt a glaſs of a fine graſs green.

Copper mineralized by ſulphur is commonly denominated the vitreous copper ore. Its colour is red, brown, blue or violet; it is generally ſo ſoft as to be cut with a knife, and ſhews a poliſhed gold-coloured ſurface where cut. As to form, it is ſometimes cryſtallized in regular figures, and ſometimes irregular. In its fracture it often ſhews violet, reddiſh and variable colours. It is much more fuſible than pure copper, and may even be melted by a candle. Its ſpecific gravity is from 2,81 to 5,338. It is found in the mines of other copper ores, and in lime-ſtone, ſpar, quartz, mica, and clay; it is the richeſt of all the copper ores, and affords from 80 to 90 per cent. of copper, 10 or 12 of ſulphur, with a ſmall proportion of iron; the red ores are the pooreſt, containing moſt iron.

This

This ore may be reduced with conſiderable facility by the blow-pipe, but it is not eaſy to ſcorify and ſeparate the laſt portions of iron and ſulphur. To analyſe the ore, Mr. Bergman adviſes a ſolution of it in five times its weight of concentrated vitriolic acid by ebullition to dryneſs, and the ſubſequent addition of as much water as will diſſolve the vitriol thus formed. This ſolution he precipitates by a clean bar of iron, and thus obtains the copper in its metallic form. If the ſolution be contaminated with iron, he re-diſſolves the impure copper thus obtained, in the ſame manner, and ſo procures a richer ſolution; which he again precipitates with iron.

The azure copper ore differs from the vitreous ore only in containing more iron, of which the proportion is from 20 to 50 per cent. Its colour conſiſts of various ſhades of blue, or reddiſh blue. It is as hard or harder than the preceding, and its fracture is reddiſh and poliſhed like glaſs. It is more difficultly reduced by the blow-pipe, and may be analyſed in the humid way by the ſame treatment.

The yellow copper ore, or copper pyrites, contains a large proportion of iron mineralized with ſulphur. It is ſometimes found cryſtallized, and ſometimes irregularly formed. The cryſtallized ſort contains the ſmalleſt portion of copper, which is ſometimes ſo trifling that the ore may be conſidered as a martial pyrites, though an experienced eye may diſcern a difference between them. The copper ſcarcely exceeds 40 per cent. in any of the ſpecimens. When this metal is ſufficiently abundant to be wrought with profit, it may be roaſted, and the ſulphur preſerved towards defraying the expences. The reſidue being expoſed to the united action of air and water, in a proper ſituation will afford the vitriol of copper, which may either be cryſtallized for ſale, or precipitated by fragments of old iron, as is advantageouſly done at the Paris-mountain mine in the iſle of Angleſea, and elſewhere. When rich in copper, it is of a brilliant yellow colour, ſometimes approaching to red; in other ſamples it is greeniſh, from the admixture of theſe two colours. The colours are more neat and lively at the place of fracture, than after expoſure to the air, which changes them. It is not very hard, is conſiderably brittle, and ſcarcely gives fire with the ſteel. Its friability is greater, the larger the proportion of ſulphur, and the leſs of iron. It affords ſeveral varieties: 1. Yellow copper ore, which is ſolid, ponderous, brilliant, and cloſe in its fracture. 2. The yellow ore, which though hard, has a laminated fracture; this is the moſt common of any. 3. Green yellowiſh copper ore; it contains the largeſt portion of ſulphur, and the leaſt of iron. 4. Cryſtallized yellow copper ore; it is the copper pyrites, properly ſo called, containing the leaſt proportion of copper and the moſt of iron. When this is met with among rich ores, it is thrown aſide becauſe of its difficult reduction and ſmall produce, which does not exceed four or five pounds of copper in the hundred weight of ore. Its colour varies, being ſometimes reddiſh, or reſembling a pigeon's neck; when yellow, it is paler than the firſt variety here mentioned. The management of this ore in the analyſis may be gathered from what has already been ſaid. It may readily be fuſed by the blow-pipe into a black matt, but it requires a continuance of the heat for a long time before the globule of copper becomes diſengaged.

The grey copper ore appears to owe its character to arſenic, which exiſts in it together with iron and ſulphur. It ſometimes contains ſilver. The copper amounts to between 35 and 60 parts in the hundred.

The colour of this ore is an obſcure or blackiſh grey: it is hard; and the

arſenic it contains renders it brittle. In its external appearance it greatly reſembles the vitreous ore of copper, but its colour is leſs bright, and inclines to yellowiſh: it is not eaſily cut with a knife, and in particular it does not take the ſhining face exhibited by the vitreous ore when cut. It is likewiſe leſs rich, and more difficult of reduction. It might with more facility be confounded with the grey ſilver ore, or fahlerts; but Mongez remarks that theſe may be diſtinguiſhed from their ſcrapings or powder, which is red in the grey ſilver ore, but grey in the copper ore. Some pieces of this ore contain no ſilver at all, but in general theſe two ores differ only in the quantity of ſilver and copper they reſpectively contain. If the product of ſilver exceed one or two per cent. it is called grey ſilver ore, according to Kirwan. Monnet diſtinguiſhes three varieties: 1. Grey copper ore, improperly called vitreous, of a poppy colour: this is the richeſt. 2. Very hard copper ore, of which abundance is found in the Hartz. 3. Grey copper ore of the colour of bronze: this is the pooreſt and moſt arſenical.

In the treatment of theſe ores with the blow-pipe, the arſenic evaporates; and if after the firſt fuſion the ſmall globule be ſuffered to cool before all the arſenic is evaporated, brown black flowers cryſtallize all round the globule. The calcination muſt be continued until the globule ſparkles, and exhibits the metallic brilliancy of fuſed copper.

The blendoſe copper ore contains, according to Kirwan, pyrites, blende, and from 18 to 30 per cent. of copper. It is of a brown colour, and of a hard, ſolid, compact, granular texture. The analyſis in the humid way is rather complicated. The metals are taken up by nitrous acid, and the copper precipitated by iron. The iron and zinc are then to be precipitated from the decanted ſolution by Pruſſian alkali. This compound precipitate muſt be expoſed to a calcining heat, then re-diſſolved in nitrous acid, and the fluid evaporated to dryneſs. Theſe laſt proceſſes completely calcine the iron, ſo that a third application of nitrous acid will diſſolve the zinc only. The quantity of this laſt metal may be known by a ſecond precipitation by the Pruſſian alkali. One hundred grains of this precipitate, waſhed and dried, are equivalent to 20 of zinc in its metallic ſtate; and 100 grains of the calcined iron are equivalent to 73 and a half in the metallic ſtate.

M. Sage, quoted by Mongez, mentions an antimonial copper ore containing arſenic and ſulphur as the mineralizer. This ore is grey like crude antimony, brilliant in its fracture, and ſuſceptible of a blue and green efflorescence. From the analyſis of this chemiſt, it contains 20 pounds of copper in the quintal, but according to that of M. Chabeauſſiere, no more than 14. It exhibits the remarkable phænomenon, that it eaſily enters into fuſion, but is very long before it is decompoſed by the fire: this circumſtance, no doubt, ariſes from the antimony it contains.

The ſchiſtoſe, or ſlaty copper ore, conſiſts of the yellow or green copper ores, the pure calces, mountain blue, and other varieties, diſperſed through ſlate as the matrix, according to Mongez. But Kirwan thinks it conſiſts of the vitreous copper ore, intimately combined with ſchiſtus, and not barely diſperſed through it in viſible particles. It is of a brown or black colour, of a lamellar texture, and very heavy. It affords from ſix to 10 per cent. of copper, and is of difficult fuſion, unleſs lime ſtone be added. It contains a little bitumen, calcareous earth, and iron, as ſchiſti do.

There is a bituminous copper ore, or pit-coal containing copper, which is found in Sweden, Hungary, and Alſatia. It takes fire without much difficulty, burns

burns ſlowly, and leaves aſhes, from which copper is extracted. This is probably the ſame ſubſtance mentioned by Brunnich on Cronſtedt, p. 698, which is called pitch-ore, in the Bannat of Temeſwar. Gellert, in his Metallurgic Chemiſtry, mentions a copper ore of the colour of pitch, which reſembles a vitrified ſcoria, and Raſpe informs us that copper has been found in Cornwall mixed with black pitchy rock oil.

Copper is alſo obtained from waters in which it is combined with the vitriolic, and ſometimes marine acid, no doubt produced by the decompoſition of ſome of the ores above mentioned. Animal and vegetable ſubſtances are ſometimes found penetrated with copper.

I ſhall conclude this article by inſerting ſome proceſſes for the reduction of copper ores in the furnace, taken from Cramer.

PROCESS I.

(Cramer's Art of Aſſaying, proceſs 36.)

To reduce and precipitate copper from a pure and fuſible ore in a cloſe veſſel.

Mix one, or, if you have ſmall weights, two docimaſtical centners of ore, beaten extremely fine, with ſix centners of the black flux; and having put them into a crucible or pot, cover them one inch high with common ſalt, and preſs them down with your finger: but let the capacity of the veſſel be ſuch, that it may be only half full; ſhut the veſſel cloſe, put it into the furnace, heap coals upon it ſo that it may be covered over with them a few inches high; govern the fire in ſuch a manner, that it may firſt grow ſlightly red-hot; ſoon after you will hear the common ſalt crackle, which will be followed by a gentle hiſſing noiſe. As long as this laſts, keep the ſame degree of fire till it ceaſes. Then ſuddenly increaſe the fire, either with the funnel and cover put upon the furnace, or with a pair of bellows applied to the hole of the bottom part, that the veſſel may become ſtrongly ignited. Thus you will reduce and precipitate your copper in about a quarter of an hour: then take out the veſſel, and ſtrike with a few blows the pavement upon which you put it, that all the ſmall grains of copper may be collected into one maſs.

Break the veſſel, when grown cold, in two, from top to bottom, as nearly as you can: if the whole proceſs has been well performed, you will find a ſolid, perfectly yellow, and malleable regulus adhering to the bottom of the veſſel, with ſcorias remaining at top of a brown colour, ſolid, hard, and ſhining, from which the regulus muſt be ſeparated by ſeveral gentle blows of a hammer: when this is done, weigh it, after having wiped off all the impurities.

A ſoft, duſty, and very black ſcoria is a ſign the fire was not ſufficiently ſtrong. Small neat grains of copper reduced, but not precipitated, and adhering ſtill to ſcorias, eſpecially not very far from the bottom, and an unequal and ramified regulus, are ſigns of the ſame thing. A ſolid, hard, ſhining, red-coloured ſcoria, eſpecially about the regulus, or even the regulus itſelf, when coloured with a like ſmall cruſt, are ſigns of an exceſs in the degree and duration of the fire.

Remarks. All the ores which are eaſily melted in the fire are not the objects of this proceſs; for they muſt alſo be very pure. Such are the vitreous copper ores; but eſpecially the green and azure-coloured ores, and the cæruleum and viride montanum, which are not very different from them. But if there is a great quantity of arſenic, ſulphur, or of the ore of another metal and ſemi-metal, joined to the ore of copper, then you will never obtain a malleable regulus of pure copper, though ores are not always rendered refractory by the preſence of theſe.

Process II.

(Cramer, proceſs 37.)

To reduce and precipitate copper out of ores rendered refractory by earth and ſtones that cannot be waſhed off.

Beat your ore into a moſt ſubtle powder, of which weigh one or two centners, and mix as much ſandiver with them. This done, add four times as much of the black flux with reſpect to the ore; for by this means the infuſible terreſtrial parts are better diſpoſed to ſcorification, and the reducing flux may act more freely upon the metallic particles, ſet at liberty.

As for the reſt, proceed as in the laſt proceſs: but you muſt make the fire a little ſtronger for about half an hour together. When the veſſel is grown cold and broken, examine the ſcorias, whether they are in the ſtate they ought to be. The regulus will be as fine and ductile as the foregoing.

Remark. As theſe copper ores contain ſcarcely any ſulphur or arſenic, the roaſting would be of no effect, and much copper would be loſt. For no metallic calx, except thoſe of gold and ſilver, improperly ſo called, can be roaſted without ſome loſs of the metal.

Process III.

(Cramer, proceſs 38.)

To precipitate copper out of an ore that contains iron.*

Act in every reſpect according to the laſt proceſs. But you will find, after the veſſel is broken, a regulus by no means ſo fine, but leſs ductile, wherein the genuine colour of the copper does not perfectly appear, and which muſt be further purified.

Remarks. The fire uſed in this operation is not ſo ſtrong as to reduce and fuſe iron alone. But copper diſſolves iron in the dry way, though of itſelf very refractory in the fire. And for this reaſon, while the ore and the flux are moſt intimately mixed and confounded by trituration, the greateſt part of the iron will combine with the copper in its metallic ſtate.

Process IV.

(Cramer, proceſs 39.)

The roaſting of pyritoſe, ſulphureous, arſenical, ſemi-metallic copper ore.

Break two docimaſtical centners of the ore to a coarſe powder, put them into a teſt covered with a tile, and place them under the muffle of a docimaſtical furnace. The fire muſt be ſo gentle, that the muffle may be but faintly red-hot: when the ore has decrepitated, open the teſt, and continue the fire for a few minutes; then increaſe it by degrees, that you may ſee the ore perpetually ſmoking a little: in the mean time, it is alſo proper now and then to ſtir it up with an iron hook. The ſhining particles will aſſume a dark red or blackiſh colour. This done, take out the teſt, and let it grow cold. If the ſmall grains are not melted, nor ſtrongly adherent to each other, the proceſs has been well conducted; but if they run again into one ſingle cake, it muſt be repeated with another portion of the ore, in a more gentle fire.

When the ore is grown cold, beat it to a powder ſomewhat finer, and roaſt it by the ſame method as before; then take it out, and if the powder is not yet melted, beat it again to a moſt ſubtle powder; in this you are to take care that nothing be loſt.

* Cramer ſtill means the calciform ores only, and not the mineralized ores of copper.

Roaſt

Roaſt the powder in a fire ſomewhat ſtronger, but for a few minutes only. If you do not then find the ore in any reſpect inclined to melt, add a little tallow, and burn it away under the muffle, and repeat the operation till the fire being very bright, you no longer perceive any ſulpuhreous, arſenical, unpleaſant ſmell, or any ſmoke; and there remains nothing but a fine ſoft powder of a dark red, or blackiſh colour.

Remarks. Every pyrites contains iron, with an unmetallic earth, with ſulphur, or arſenic, and moſt commonly both. Beſides, as the copper in pyrites is exceedingly variable in quantity, their diſpoſition in the fire muſt vary accordingly. For inſtance, the more copper there is in pyrites, the more it inclines to colliquation. The more ſulphur and arſenic it contains, the more fuſible it will be; and the more iron and unmetallic earth it contains, the more refractory it will prove in the fire. If ſuch pyrites melt in the roaſting, as is the caſe with ſome of them, or if they grow but red hot, the ſulphur and arſenic become ſo ſtrictly united to the fixed part, that it is almoſt impoſſible to diſſipate them. For in this caſe, when the matter is again reduced into a powder, a much greater time and accuracy are required in the management of the fire to perform the operation. For this reaſon, it is much better to repeat it with new pyrites. But you muſt roaſt no more than twice the quantity at once of the ore you are inclined to employ in the foregoing experiment; in order that, if the precipitation by fuſion ſhould not ſucceed, there may ſtill remain another portion for uſe, inſtead of your being obliged to repeat a tedious roaſting. If you obſerve the ſigns of a ferruginous refractory pyrites, the operation muſt be performed with a ſtronger fire, and with much greater ſpeed. However, you muſt be careful not to perform it with too violent a fire: for a large proportion of copper is deſtroyed not only by the arſenic, but by the ſulphur; and this happens even in veſſels nearly cloſed, when the ſulphur is expelled by a fire not quite ſo ſtrong. By repeated and gentle ſublimation of the ſulphur in a veſſel, both very clean and well cloſed, this fact will be clearly ſeen.

When the greateſt part of the ſulphur and the arſenic is diſſipated, you may make a ſtronger fire: but then it is proper to add a little fat. Cramer here accounts for the advantage produced by the fat, by obſerving, that it diſſolves mineral ſulphur. In fact, it reduces and volatilizes the laſt portions of arſenic, and at the ſame time, as he juſtly remarks, prevents that extreme ſcorification of the copper which would greatly impede its ſubſequent reduction. Hence he adds, the reaſon is plain, why aſſayers produce leſs metal in the trying of veins of copper, lead, and tin, than ſkilful ſmelters do in large operations. For the former perform the roaſting under a muffle, with a clear fire, and without any oily reducing matter; whereas the latter perform it in the middle of charcoal or of wood, which conſtantly tend to reduce the calces.

The darker and blacker the powder of the roaſted ore appears, the more copper you may expect from it. But the redder it looks, the leſs copper and the more iron it affords; for roaſted copper diſſolved by ſulphur, or the acid of it, is very black; and iron, on the contrary, very red.

Process V.

(Cramer, proceſs 40.)

The precipitation of copper out of roaſted ore of the laſt proceſs.

Divide the roaſted ore into two parts, and reckon each of them a centner: add to it the ſame weight of ſandiver, and four times as much of the black flux,

and

and mix them well together. Manage the reſt of the operation in every reſpect according to proceſs 1. The precipitated regulus will be ſlightly malleable, ſometimes brittle, now and then very much like pure copper in its colour, but ſometimes whitiſh, and even blackiſh. Whence it is moſt commonly called black copper, though it is not always of ſo dark a colour.

It is eaſy to conceive, that there is as great a difference between the ſeveral kinds of the metal called black copper, as there is between the pyritoſe and other copper ores accidentally mixed with other metallic and ſemi-metallic bodies. For all the metals, the ores of which are intermixed with the copper ores, being reduced, are precipitated together with the copper; which is brought about by means of the black flux. Hence, iron, lead, tin, the metallic part of antimony, biſmuth, are moſt commonly mixed with black copper in a variety of different proportions. Indeed, it is ſelf-evident, that gold and ſilver, which are diſſolvable by all theſe matters, are collected in ſuch a regulus, when they have previouſly exiſted in the ore. And moreover, ſulphur and arſenic are not always entirely abſent. For they can hardly be expelled ſo perfectly, by the many preceding roaſtings, but there will remain ſome veſtiges of them, which are not diſſipated by a ſudden melting, eſpecially in a cloſe veſſel, wherein the flux ſwimming at top hinders the action of the air. Indeed, arſenic is rather fixed by the black flux, and aſſumes a reguline ſemi-metallic form, while it is at the ſame time preſerved from diſſipating by the copper.

Process VI.

(Cramer, proceſs 44.)

To reduce black copper into pure copper by ſcorification.

Separate a ſpecimen of your black copper, of the weight of two docimaſtical centners at leaſt; and perform this in the ſame manner, and with the ſame precautions, as if you would detect a quantity of ſilver in black copper.

Then with lute and coal-duſt make a bed in the cavity of a moiſtened teſt: when this bed is dry, put it under the muffle of the docimaſtical furnace, in the open orifice of which there muſt be bright burning coals, with which the teſt muſt likewiſe be on all parts ſurrounded. When the whole is perfectly red-hot, put your copper into the fire alone, if it contains lead; but if it is entirely deprived of it, add a ſmall quantity of glaſs of lead, and with a pair of hand-bellows increaſe the fire, that the whole may ſpeedily melt: this done, let the fire be made a little leſs violent, and ſuch as will be ſufficient to keep the metallic maſs well melted; and not much greater. The melted maſs will boil, and ſcorias will be produced, that will gather at the circumference. All the heterogeneous matters being at laſt partly diſſipated, and partly turned to ſcorias, the ſurface of the pure melted copper will appear. As ſoon as you perceive this, take the pot out of the fire, and extinguiſh it in water: then examine it in a balance; and if lead has been at firſt mixed with your black copper, add to the regulus remaining of the pure copper, one fifteenth part of its weight which the copper has loſt by means of the lead; then break it with a vice; and thus you will be able to judge by its colour and malleability, and by the ſurface of it after it is broken, whether the purifying of it has been well performed, or no. But whatever caution you may uſe in the performing of this proceſs, the product will notwithſtanding be always leſs in proportion than what you can obtain by a larger operation, provided the copper be well purified in the ſmall trial.

Remarks. This is the laſt purifying of copper, whereby the ſeparation of the

heterogeneous bodies, begun in the foregoing proceſs, is completed as perfectly as it poſſibly can be. For, except gold and ſilver, all the other metals and ſemi-metals are partly diſſipated and partly burnt, together with the ſulphur and arſenic. For in the fuſion they either turn of themſelves to ſcoria or fumes, or this is performed by means of iron, which chiefly abſorbs ſemi-metals, ſulphur, and arſenic, and at the ſame time they accelerate its deſtruction. Thus the copper is precipitated out of them pure: for it is ſelf-evident, that the unmetallic earth is expelled, the copper being reduced from a vitreſcent terreſtrial to a metallic ſtate; and the arſenic being diſſipated, by means of which the ſaid earth has been joined to the coarſer reguli of the firſt fuſion. But there is at the ſame time a conſiderable quantity of the copper that mixes with the ſcorias, though a great part of it may be reduced out of them by repeating the fuſion.

The fire in this proceſs muſt be applied with all poſſible ſpeed, to make it ſoon run: for, if you neglect this, much of your copper is burnt; becauſe copper that is only red-hot cleaves much ſooner, and in much greater quantity, into half-ſcorified ſcales, than it is diminiſhed in the ſame time when melted. However, too impetuous a fire, and one much greater than is neceſſary for its fuſion, deſtroys a much greater quantity of it than a fire only ſufficient to fuſe it. For this reaſon, when the purifying is finiſhed, the melted body muſt be extinguiſhed in water together with the veſſel, leſt, being already grown hard, it ſhould ſtill remain hot for a while; which muſt be done very carefully to prevent dangerous exploſions.

The ſcoria of the above proceſs frequently contains copper. To extract which, let two or three docimaſtical centners of the ſcoria, if it be charged with ſulphur, be beat to a ſubtle powder, and mix it, either alone, or, if its refractory nature requires it, with ſome very fuſible, common, pounded glaſs, without a reducing ſaline flux, and melt it in a cloſe veſſel, and in a fire having a draught of air; by which you will obtain a regulus.

But when the ſcoria has little or no ſulphur at all in it, take one centner of it, and with the black flux manage it as you do the fuſible copper ore (proceſs I.); by which you will have pure regulus.

Process VII.

The following proceſs is tranſlated from Mr. Gellert's Elements of Eſſaying*.

To eſſay copper ores.

Roaſt a quintal of ore (after the manner deſcribed in proceſs IV.); add to it an equal quantity of borax, half a quintal of fuſible glaſs, and a quarter of a quintal of pitch; put the mixture in a crucible, the inner ſurface of which has been previouſly rubbed with a fluid paſte of charcoal-duſt and water; cover the whole with pounded glaſs mixed with a little borax, or with decrepitated ſea-ſalt: put a lid on the crucible, which you will place in an air furnace, or in a blaſt-furnace: when the fire ſhall have extended to the bottom of the coals, let it be excited briſkly during half an hour, that the crucible may be of a briſk red colour: then withdraw the crucible, and when it is cold break it: obſerve if the ſcoria be well made: ſeparate the regulus, which ought to be ſemi-ductile, and weigh it. This regulus is black copper, which muſt be purified as in proceſs 6.

If the ore be very poor, and enveloped in much earthy and ſtony matters, to a quintal of it, a quintal and a half of borax, a quarter of a quintal of pitch, and ten pounds of calx of lead or minium, muſt be added. The calx of lead will be

* Notes to Macquer's Dictionary. Art. Ores.

revived,

revived, and will unite with the ſcattered particles of the copper, and together with theſe will fall to the bottom of the crucible, forming a compound regulus. When the ores of copper are very rich, half a quintal of borax and a quarter of a quintal of glaſs will be ſufficient for the reduction. If the ore is charged with much antimony, a half or three quarters of a quintal of clean iron filings may be added; otherwiſe the large quantity of antimony might deſtroy the copper, eſpecially if the ore contained no lead. If iron be contained in copper ore, as in pyrites, ſome pounds of antimony, or of its regulus, may be added in the eſſay; as theſe ſubſtances more readily unite with iron than with copper, and therefore diſengage the latter metal from the former.

ORES OF GOLD. From the unchangeableneſs of gold by the ſolvents uſually diſengaged in nature, it is comparatively very ſeldom found but in the native ſtate. In this ſtate it is never abſolutely pure, but always mixed either with ſilver, copper, or iron. It is uſually found in rocks of quartz, always in ſmall particles or maſſes. The ſands of ſeveral rivers afford it in ſmall plates or leaves. Moſt great rivers carry gold with them, even ſuch as do not take their riſe in mountains where gold is found. In the ſouth of France, in Tranſylvania, and elſewhere in Europe, this gold is ſeparated by waſhing off the ſand; but the produce is not ſufficient in general to pay any rent, or employ capital. It merely affords ſubſiſtence to ſuch poor families as apply to this ſpecies of induſtry, particularly after the torrents occaſioned by heavy rains. If a hundred pounds of ſand contain twenty-four grains of gold, it is ſaid the ſeparation is worth attending to; but in Africa, five pounds of ſand often contain ſixty-three grains of gold. The heavieſt ſand, which is often black or red, yields moſt.

Daubenton diſtinguiſhes eight varieties of native gold. 1. In powder. 2. In grains. 3. In ſmall ſpangles. 4. In maſſes. 5. In filaments. 6. In branches like vegetables. 7. In ſmall plates; and 8. In octohedral cryſtals.

Gold is found mineralized by ſulphur together with iron, which is ſuppoſed to be the connecting medium. This is the auriferous pyrites. It is cloſe and compact, of a brighter and more lively yellow than the ordinary pyrites; notwithſtanding which, they are, as Mongez ſays, very difficult to be diſtinguiſhed. The gold cannot be extracted by aqua regia, or by amalgamation, but the laſt mentioned author gives the following ſimple method for this purpoſe: Take a ſmall quantity of this pyrites, and digeſt it in the nitrous acid. All the foreign matters will be diſſolved, except the gold and ſulphur, which fall to the bottom. Waſh the reſidue under water till nothing more remains but a yellow brilliant powder. This is the gold. According to M. Sage, one half as much more gold is extracted from the pyrites by this method, than by treatment with lead. This pyrites, according to Cronſtedt, ſometimes contains an ounce of gold in the hundred pounds. Some ſamples contain a portion of zinc as well as iron, and even copper, which gives the maſs a greeniſh tinge. It is found at Adelfors in Sweden, in Hungary, Mexico, the iſland of Sumatra, Switzerland, and Dauphiny in France. Cronſtedt remarks, that no pyrites ought to be deſpiſed, which are found in tracts where gold ores are obtained. Brunnich on Cronſtedt affirms that the Tranſylvanian gold pyrites, in which no gold can be diſcovered by the eye, contained from fifty to one hundred and ten ounces, and upwards, in the hundred weight: and that thoſe where the gold appears in the pyrites like mixed Spaniſh ſnuff, contained two hundred and fifty ounces, but they are very ſcarce.

Gold is found in Hungary united with mercury and ſulphur. It is the auriferous cinnabar.

There is likewiſe a blend or ore of zinc found at Chemnitz in Hungary, which contains ſilver and gold. It is uſually of a red or black colour.

The auriferous ore of Nagayac in Tranſylvania is mentioned by Bergman as a compound of gold, ſilver, lead, and iron, mineralized by ſulphur. Sage, quoted by Mongez, remarks, that there are few ores which contain ſo numerous an aſſemblage of metallic matters. For it includes the red foliated and tranſparent blend, the ſpecular ore of antimony, copper, ſilver, and iron. This ore is of a gray colour, more or leſs obſcure, in irregular maſſes; but ſometimes, alſo, it is compoſed of ſlender, flexible leaves of no great conſiſtency; it may be cut with a knife, is ſoluble in acids with efferveſcence, and the ſolution appears clear and colourleſs. It often, according to Mongez, contains aerated manganeſe, and may be eaſily diſtinguiſhed from all the other gold ores by expoſure to the fire. For the gold readily melts by the aſſiſtance of the lead which is preſent, and exudes through the maſs into ſmall globules. All the ſpecimens are not equally rich in gold. Baron Born, in his letter to Mr. Ferber, enumerates the following varieties: 1. The ore of gold mineralized with galena, iron, and volatile particles. It is lamellated, gray, compoſed of ſmall, flexible, brilliant plates, as above deſcribed. It is found among red felt ſpar, or fat quartz. 2. Gold mixed with the gray ſilver ore, or molybdena, or antimony. 3. Gold mixed with iron and ſulphurated arſenic. Its texture is filamentous, and its colour yellowiſh. It ſlightly reſembles the arſenical ſilver ore, mineralized by the reddiſh blend.

The auriferous ore of Nagayac, urged with the blow-pipe upon the charcoal, liquefies, and affords a white globule reſembling ſilver, which is brilliant and malleable. Borax diſſolves it without efferveſcence, or change of colour. Microcoſmic ſalt attacks it with efferveſcence, and aſſumes an obſcure red colour, which diſappears by continuing the fuſion for a certain time. A metallic globule is perceived on the ſurface of the flux.

For other remarks on the treatment of gold and its ores, ſee the article GOLD. The new proceſs of amalgamation, invented by Baron Born, has very much engaged the attention of mineralogiſts; for which reaſon, as well as for its own intrinſic value, I ſhall here give an account of the proceſs, from Raſpe's tranſlation of the Baron's work on this ſubject*.

The amalgamation of gold and ſilver ores, in large operations, as well as in ſmaller aſſays, requires the following diſtinct operations:

Stamping, grinding, and ſifting.
Calcination, and repeated grinding and ſifting.
Trituration.
Waſhing of the reſiduum.
Eliquation of the amalgama.
Heating of the ſame.
Diſtillation of the quickſilver preſſed from the amalgama.
Refining of the heated quickſilver; and laſtly,
Management, uſe, and refining of ſuch reſidua as ſtill appear to contain ſome of the nobler metals.

Stamping, grinding, and ſifting.

By theſe operations the picked ores, reguli, black copper, and reguline mixtures (ſpeiſs) of metals and ſemi-metals are reduced into fine powder; and their ſurfaces being thus increaſed, they mix and calcine better with the common or

* See the Chemical Journal, iii. 63.

rock ſalt, which is added to them; otherwiſe, the calcining fire and the air could not act ſufficiently on the groſſer particles, nor could the vitriolic and marine acids * properly penetrate them, or a perfect deſulphuration and decompoſition of ſuch ſubſtances be brought on, in which the gold and ſilver particles are d iſ guiſed.

Theſe operations are performed at Glaſshutte, near Schemniz in Hungary, in dry ſtamps and mills; but at Joachimſthal in Bohemia, wet ſtamps have been ſubſtituted, by which means the loſs of duſt unavoidable in the dry grinding, and alſo the injury otherwiſe done to the health of the workmen, are prevented.

Calcination.

Sulphur can be expelled from ores in open fire and in cloſed veſſels, but imperfectly, unleſs ſome proper ſubſtance be added. Thus, for example, corroſive ſublimate is uſed in order to ſeparate the ſulphur from ſome ores; in this caſe the concentrated marine acid unites with the metallic, ſemi-metallic, and ſoluble earthy particles, paſſes into the receiver with the arſenic and antimonial calx in the form of butter, and the diſengaged quickſilver ſublimates with the diſengaged ſulphur in the form of cinnabar.

From this an idea may be formed of the calcination of thoſe ores, which, beſides particles of native metal, contain diſguiſed gold and ſilver, which would never be got entirely by waſhing or other mechanical contrivances, without ſome chemical aſſiſtance. This is their calcination. By fire and air it decompoſes the ores, expels the ſulphur, puts the metallic and ſemi-metallic particles into a calciform ſtate, and, freeing the noble metals from their diſguiſes, exhibits them naked in their metallic form.

If there be ſulphur enough, or even a ſuperabundance of it, calcination will produce this deſirable effect without any other addition. But as the vitriolic acid acts on the ores, and diſengages the gold and ſilver particles only in proportion as it is produced from the ſulphur in more or leſs quantity, it is ſafer to depend on the marine rather than the vitriolic acid: and though common or rock ſalt, added in the proceſs of amalgamation of well calcined ores, anſwers this end in ſome reſpects, yet it will ſerve better when mixed in proper proportions with the earthy or metallic ores before they go to the calcining fire, thus undergoing with them a ſimilar calcination. The quantity in which it is to be added muſt be determined by experience. When picked and halvan ores are calcined with common ſalt, the ſulphur and arſenic, if any, begin firſt to be diſengaged. Part of the ſulphur flies off undecompoſed, a great part is converted into phlogiſton and vitriolic acid, which laſt, uniting with the alkaline and metallic earths of the baſe metals and ſemi-metals, but in particular with the mineral alkali of the common ſalt, forms with the firſt, different earthy and metallic (more or leſs ſoluble) neutral ſalts, and with the laſt, Glauber's ſalt. The marine acid thus diſengaged begins now to act like the vitriolic acid, and is abſorbed equally by the earths and the metallic calces.

* The vitriolic acid is produced in the act of calcination, by the decompoſition of the ſulphur contained in the ores, and the marine acid proceeds from the common ſalt, which is purpoſely added to the ores, and which is decompoſed by the vitriolic acid. A Glauber's ſalt is formed by the union of the laſt mentioned acid with the baſes of the common ſalt; and the marine acid, thus ſet at liberty, attacks, diſſolves, and unites with the earthy matter, and alſo with the imperfect metals of the ores, by which means the particles of gold and ſilver are freed from their diſguiſe or heterogeneous coverings, and laid open to, and fitted for combination with the quickſilver. This is in few words the theory of the proceſs.

The marine acid conſequently penetrates the alkaline and metallic earths more completely than the vitriolic alone; for if there be ſalt enough, it decompoſes all the vitriolic, earthy, and metallic neutral ſalts, by its different elective attractions, forming therewith various new deliqueſcent and very ſoluble earthy and metallic neutral ſalts, by which all the diſguiſed gold and ſilver particles are diſengaged, laid bare, and fitted for amalgamation.

When auriferous, or ſilvery reguline mixtures of baſe metals and ſemi-metals * (ſpeiſs) undergo calcination, fire and air will produce it in part, but ſlowly and imperfectly; whereas with common ſalt, or properly its acid, it ſucceeds quicker and better. There is no ſulphur here, nor its acid, to decompoſe the ſalt and diſengage its acid; but common ſalt decompoſing by continued heat, its acid is as it were phlogiſticated by the action of the fire, ſeparates from its alkaline baſis, and acts immediately as a ſolvent of the metallic and ſemi-metallic particles. The elective attraction of theſe metals and ſemi-metals ſeems even to aſſiſt the decompoſition and power of the ſalt.

The different mixtures of theſe reguli (ſpeiſs) account for the different muriatic, metallic, and ſemi-metallic neutral ſalts. For inſtance, the reguli produced by the fuſion of the Hungarian fallow, or gray copper ores, conſiſt of antimonial regulus, copper, gold, and ſilver, and ſometimes alſo of ſome arſenic and iron, which in the reguli of common antimonial gray copper ores, is but in a very inconſiderable proportion. The muriatic acid, diſengaged from the ſalt, unites (gold and ſilver excepted) with the other metals and ſemi-metals, which by calcination leave the gold and ſilver bare and undiſguiſed.

The ſame thing happens in the calcination of auriferous or only ſilvery black coppers. By the addition of common ſalt, the copper, iron, arſenic, and ſometimes the antimonial particles are not only calcined, but alſo moſt of the antimony and arſenic is volatilized and deſtroyed.

The cobalt reguli produced in the treatment of arſenical cobalt and ſilver ores, contain very often a great quantity of biſmuth. The calcination with common ſalt acts upon them in a ſimilar manner; but ſhould they abound in biſmuth, which is exceedingly fuſible, this ſemi-metal muſt be taken out by eliquation before they can be well calcined, otherwiſe the biſmuth would run, and, if not wholly prevent, yet very much hinder the calcination of the other metallic and ſemi-metallic particles.

In calcining reguline mixtures, which abound in antimony, and particularly in arſenic, it has been frequently found that more or leſs quantities of ſilver and copper are carried off by the antimonial and arſenical butter, which ariſes from the marine acid, chiefly when the calcining heat has been too ſudden and briſk for the purpoſe of a quick calcination of the antimony, and expeditious expulſion of the arſenic; for theſe volatile ſemi-metals acquire, by the muriatic acid, a much greater than their natural power to carry off and volatilize even the fineſt metals.

Whatever theſe reguline mixtures are, or may be, they muſt have gone through the ſtamps and mills, and have been completely pulveriſed before they can be committed to the calcining fire, which is a flaming fire kept up by the worſt of fuel; or to the calcining furnace, which conſiſts of two hearths, which, taken together, are 11 or 12 feet by five, of a grate, ſmoke and duſt chambers, communicating with a flue, and ſliding duſt-ſtoppers or duſt dampers.

* The reguline mixtures are produced in the fuſion of cobaltic, arſenical, and antimonial ores.

The proportion and mixture of the picked and halvan or ſtamp-ſtuff is (in Hungary) determined by and depends upon the reſpective produce of the mines and ſtamps, which is commonly two in three; and with regard to the ſilver, upon their average produce. The proportion of the ſalt is regulated and determined by the more or leſs quantity of the ſulphur of the ſaid picked and halvan ores.

Thus, for example, a whole work, parcel, or ſtem of a calcining furnace in the quick-mills in Lower Hungary, conſiſts of 30 cwt. one-third or 10 cwt. of which are pulveriſed picked ore, and two-thirds or 20 cwt. pulveriſed ſtamp or halvan-ore. Sometimes it conſiſts of two-fifths of the former and three-fifths of the latter; and in that porportion it contains, upon an average, three and a half, three and three-quarters, or four ounces of ſilver per cwt. To ſuch a mixture they generally add eight per cent. of rock-ſalt *.

The calcination of ſpeiſs or reguline mixtures of baſe metals and ſemi-metals, of ſilvery black coppers, and of leadiſh ores, requires, over and above the ſalt, an addition of quick-lime, from four to ten and twelve per cent. For theſe metallic mixtures otherwiſe riſe amazingly in the calcining heat, and the ſpeiſs and black coppers are in particular apt to turn clammy, and to leave clots in which many particles remain uncalcined; but both theſe inconveniences are counteracted by the lime. It prevents the immediate contact of the metallic particles, and their running in the calcining fire: moreover, as it increaſes the ſurface of the whole mixture, the ſingle parts of the ſame are more effectually acted upon, calcined, and laid bare by the fire, air, and muriatic acid.

Even the ſilver regulus, and raw-ſtone, and the lead and copper reguli, bear a moderate addition of lime.

When the furnace is properly heated, and the doors of the duſt-chambers, and the ſliding-dampers, or duſt-catchers of the flue, are ſhut, the whole parcel of ore (viz. 30 cwt.) is run by wheel-barrows on the flat top of the furnace, when having been equally ſpread into an even ſurface, the proper proportion of ſalt and lime is ſifted over it, and the whole is turned and worked with iron rakes and crooks, in every direction, until the whole is perfectly and equally mixed. Thus prepared, it is ſpread into a ſquare ſurface, and marked into equal diviſions, which, in due ſucceſſion, are let down (in 8 cwt. parcels) on the upper hearth, by means of a funnel, which opens upon it through the lower vault or floor of the furnace. On this hearth it muſt be ſpread and extended equally, that the moiſture of the ſtamp or halvan-ore may be expelled, before it is ſhoved down on the lower hearth: after which the upper hearth is immediately filled again with another quantity, that exſiccation and calcination may be performed at the ſame time, by the ſame fire.

In the calcination, the following phenomena take place: on the ſurface of the picked and halvan-ores, when brought on the lower hearth, and ſtirred, an undulating motion is obſerved, and a volatile ſulphureous acid ſmell is perceived; after which the ſulphur begins to diſengage itſelf burning, covering the whole (when the ores are very ſulphureous) with a blue flame, and flying off at laſt in the form of a whitiſh thick ſuffocating ſmoke.

Whilſt the ſulphur is thus diſengaged and decompoſed in a low or gentle fire, the vitriolic acid, thence produced, decompoſes the common ſalt, combines

* If pan-ſalt ſhould be uſed, and prove of an inferior quality on account of fixed ammoniac *(calx ſalita)* and magneſia, left in it by too briſk boiling, &c. then the proportion muſt be different. Eight per cent. of pan-ſalt will do for ſilver ore; but copper regulus frequently requires ten per cent. and black copper twelve per cent.

with its mineral alkali, and diſengages the marine acid, which preſently unites with the alkaline and metallic earths. At this time the ore begins to clot, to riſe, extend, and increaſe in bulk and ſurface. It begins to look like wet aſhes and to diffuſe a mixed, ſulphureous, ſaline, acid ſmell, which proceeds from a lighter whitiſh or grayiſh blue ſmoke flying off from the ſurface.

From this inſtant the fire and furnace may be kept a little brighter, yet the ore muſt be continually ſtirred and turned over from one ſide of the furnace to the other; otherwiſe it would be calcined unequally, and ſome particles would remain undecompoſed. If the furnace and fire were kept too bright, the ſulphur, arſenic, and ſaline acid particles, too briſkly expelled, would unavoidably carry along with them, and volatilize many other, nay even metallic particles *.

When the ſulphur begins to diſengage, the ore changes its colour; it changes again when the calcination is over at its riſing and ſubſidence. The ſulphureous acid ſmell diſappears when the ore that had been riſing begins to ſink, and the clotting ceaſes, for then part of the muriatic acid flies off. On taking a ladle full of it for proof, or even on ſmelling the whitiſh rarefied ſmoke near the back-door of the furnace, the ſmell of pure marine acid, or of volatile ſpirit of ſalt, is perceived.

Moſt ores and mixtures of ores, chiefly when containing a great proportion of pyrites, or when there happens to be ſulphurated copper ore, ſhew at this period a luminous phoſphoric appearance, when ſuddenly taken from the hearth, and immediately examined in the dark. In a moderate heat and cold weather, they likewiſe ſhew, during the ſtirring, bright luminous ſparks, flying and ſcattering about like fire-work.

When the ſulphur is ſufficiently expelled, and part of the marine acid is gone; when the whole begins to ſubſide, and the clotting to be leſs; and when all the above-mentioned phenomena have appeared, then the calcination s deemed to be perfect.

The colour of the calcined ores and halvans is generally red, reddiſh gray, dark red, or red-brown, according to the proportion of the earthy and metallic particles, or of the ſulphur they contained. They are of a lighter and higher red when very earthy; brown when very coppery, or mixed with manganeſe; and yellowiſh red when lead prevails in their mixture.

Copper reguli, containing a much greater proportion of ſulphur, muſt undergo a longer calcining heat than other mixtures of ores and halvans. When mixed with lead, or antimony and arſenic, they muſt be put to calcine not only with common ſalt, but alſo with a proportionate quantity of quick-lime, that the exceſs of muriatic acid may be taken from the butter of antimony and arſenic, and from the plumbum corneum which are produced during the calcination, and be abſorbed by the lime, which prevents the untoward clotting of the particles.

The ſame cautions muſt be obſerved in the calcination of the reguline mixtures (ſpeiſs) of baſe metals and ſemi-metals, and of the ſilvery black coppers, for they alſo contain a conſiderable proportion of antimony and arſenic. If not calcined with lime, along with the common ſalt, they pack at the very inſtant the regulus of antimony and arſenic is calcined and volatilized, in the form of a

* Though the fire be ever ſo cautiouſly conducted, ſome particles of the ore will be carried off and loſt. This chiefly happens in the firſt ſtage of the fire, for then during the ſtirring of the ore, ſome particles are taken up and carried away by the current of rarefied air, or during the riſing of the mixture, by means of the ſulphur and marine acid. This may be in ſome meaſure prevented by keeping the back-door of the upper hearth ſhut; by avoiding to ſtir the mixture while it duſts, &c. &c.

white

white very thick ſmoke, which is brought about very expeditiouſly by the diſengaged marine acid.

The reguline mixtures (ſpeiſs) of metals and ſemi-metals, and the black coppers, containing little or no ſulphur, the common ſalt calcined with them is decompoſed by the action of the fire. The marine acid, thus ſet free, promotes their calcination, and forms with their calces different perfect or imperfect neutral ſalts, diſengages the diſguiſed gold and ſilver particles, whilſt the mineral alkali remains free and in a cauſtic ſtate: for, in the dry way, the marine acid leaves its alkali, and combines with the metals and their calces; but, by ſubſequent ſolution in water, it returns to the alkali, forming again with it common ſalt, and conſequently lets go the metals, ſemi-metals, and earthy particles, before in ſolution.

In the calcination of theſe metallic mixtures and the copper reguli, the beforementioned luminous phoſphoric appearance does not take place; but the flame which paſſes over them affects various colours, and in particular the red and blue, both owing to volatilized particles of copper.

When antimonial ſtone, copper reguli, and reguline mixtures of metals and ſemi-metals are put to calcine, the antimony calcines firſt, forming a white calx in the flues and other paſſages; arſenical mixtures diffuſe a white ſmoke and garlic ſmell; thoſe which abound in lead and zinc (which laſt require a ſtronger and longer fire) produce ſaturnine zincous ſmoke and white flowers.

When the calcination of theſe metallic mixtures is perfected, and the remainder is cooled, their calces appear browniſh gray, or dark gray; and thoſe of the ſtone and copper reguli of a more or leſs ſaturated red colour, except thoſe which abound in lead.

The ſureſt ſymptoms, however, of their perfect calcination, are collectively the riſing and ſinking of the mixtures, their colour, and the acrid ſmell of the marine acid. Then only the gold and ſilver particles may be deemed to be fully diſengaged.

Sifting and grinding after calcination.

The grinding and ſifting of the ſtuff is as neceſſary after as before calcination, becauſe the ſtamp and halvan-ſtuff, which is mixed up with the picked ore, could not be ſifted or ground previous to its calcination, on account of its moiſture. This further grinding and ſifting ſerves likewiſe fully to pulverize and equalize the clots of the reguline mixtures (ſpeiſs) of metals and ſemi-metals, and of the copper reguli.

If theſe coarſer particles were ſuffered to remain as they are, they might ſtill diſguiſe many gold and ſilver particles, and guard them againſt amalgamation.

This repeated grinding and ſifting may be diſpenſed with when the whole ſtuff is of an equal ſize and ſufficiently fine; but its clots will at any rate require examination, whether they be ſoluble in water or not, for thoſe of leady and metallic mixtures remain inſoluble. If ſoluble, and not leaving ſharp coarſe particles between the fingers, they want neither grinding nor ſifting, but they muſt go through both theſe operations when inſoluble, and when they betray ſuch coarſe particles on being rubbed between the fingers.

Trituration, boiling, and amalgamation of the calcined ſtuff.

By amalgamation we underſtand that mechanical and chemical operation, in which, by means of quickſilver, heat, uninterrupted motion, and ſucceſſive contact of the particles,—gold and ſilver (previouſly diſengaged from their diſguiſes by calcination and pulveriſation) are extracted from their earthy, metallic, or mineralized matrixes, and combined with quickſilver.

If the ores have been duly pulveriſed and calcined, the ſucceſs of trituration or amalgamation moſtly depends on the proper proportions of the quickſilver and water which are added to the ſtuff: it likewiſe depends on the goodneſs and conſtruction of the ſtirring apparatus, by which the whole mixture is kept in conſtant motion and mutual contact. Even the degree of heat, and the quickneſs of the trituration or ſtirring, contribute to the quicker and perfect amalgamation.

To determine the quantity of quickſilver, the weight and bulk of the calcined ſtuff are to be conſidered. The lighter the ſtuff, the more voluminous it will prove, and conſequently the gold and ſilver will be the more diſperſed. In this caſe the quantity of quickſilver muſt be proportioned to the maſs. Thus, for example, 2 cwt. of picked ore and halvans are more bulky than 2 cwt. of calcined copper regulus or other reguli. The former, therefore, require a larger quantity of quickſilver.

Both in ſmall and great operations, experience has determined, that an exceſs of quickſilver is never hurtful, and that, on the contrary, a ſcanty proportion is attended with loſſes. It may be taken in the proportion of one to two, that is 1 cwt. of quickſilver to 2 cwt. of ſtuff. In this proportion it does not increaſe the coſt of waſhing and preſſing, nor is any loſs of quickſilver incurred; the full produce of noble metal is thus ſecured, and the reſiduum is left poorer.

The veſſels or boilers, in which the quickſilver and ſtuff are triturated, are of copper, of an inverted conical form, and with a concave bottom. No boiling heat required: a heat of 50° or 60° is ſufficient.

No more water is required than what will ſoak into and make the ſtuff liquid. Exceſs of water makes the quickſilver ſink too faſt, and keeps the lighter and finer particles of the metals floating on the ſurface; which of courſe prevents the perfect ſucceſs of the operation. On the other hand, too little water leaves the ſtuff too thick, which makes the ſtirring very troubleſome; moreover, the evaporation of the water ſoon forms a dry and hard cruſt on the ſides of the boiler, which is attended with loſs of ſilver in the reſiduum. Experience muſt determine the proper reſpective meaſure of water.

The ſtirring apparatus is put into motion by means of a water-wheel.

The ſtirrers or ſtirring racks (which were at firſt made of copper, but have ſince been found to anſwer better when made of wood) are circular ſegments correſponding with the ſides and bottom of the boiler.

Experience only can determine how long the reſpective ſtuffs muſt be triturated with quickſilver. It has been found that ſome ſtuff yields its gold and ſilver to the quickſilver, perfectly and completely within eight or ten hours; other mixtures require a trituration of 12 or 15 hours. Exceſs of time or longer trituration is never hurtful; too little of it will often leſſen the produce.

Waſhing of the triturated leavings, or reſiduum.

The object of the trituration already deſcribed, was to unite the gold and ſilver particles of the calcined ſtuff into an amalgama with quickſilver: the object of this waſhing, is the ſeparation of this rich amalgama from the leavings or reſiduum.

This waſhing is performed in a large tub, of a conical form, with a rake within it, contrived ſo as to be thrown into a rotatory motion, by a water-wheel, or by hands; with ſide cocks for drawing off the water; and with a bottom cock for tapping off the amalgama or quickſilver.

The

The particles of quickſilver and amalgama, kept floating in the whole liquid maſs, by the continual rotation of the rake, ſink by their gravity, and collect in the concave bottom of the tub, above the cock; but the remaining ſtuff or ore and ſtony matter, being much lighter, is kept floating. When the whole has been ſufficiently ſtirred about in this manner with the water, the bottom cock of the waſhing-tub is opened, and the quickſilver and amalgama are thereby let out; after which one (or more) of the ſide cocks (which are fixed at different heights) is opened to let out the thin liquid ſtuff *.

Eliquation of the quickſilver and amalgama.

The quickſilver, triturated with rich ſtuffs, is ſtrained through a kind of filtrum, for the purpoſe of bringing the gold and ſilver particles into a ſmaller compaſs, and of ſeparating them from the exceſs of quickſilver; although the whole can never be ſeparated but by fire.

This is done by means of a box, on the circular opening of which lies an iron ring, to which is fixed a bag of linen damaſk. The quickſilver (its ſurface having been previouſly cleanſed with a ſponge from any muddy water or ſtuff that might adhere to it) is poured in ſmall quantities into this bag by one perſon, whilſt another preſſes it with his hands, until the ball of amalgama, collecting and forming apace, does no longer yield any quickſilver. When the ball becomes too big for preſſure with two hands, it is taken out, and another is formed in the ſame manner, until all the quickſilver is gone through the bag. The balls of amalgama are put into a wooden box.

The quickſilver which has been ſtrained through the bag (and which always contains from 20 to 30 penny-weights of gold and ſilver per cwt.) is collected in a reſervoir under the box, and ſerves again for trituration with freſh quantities of ore †.

Heating and ſublimation or diſtillation of the amalgama.

The amalgama balls, obtained by preſſing or eliquating the quickſilver, conſiſt (according to the different degrees of preſſure they underwent) of one part ſilver, and four, five, or ſix parts quickſilver. This is expelled from them by fire in cloſe veſſels. It is a diſtillation *per deſcenſum*, performed in large caſt-iron pots put over each other. The fire is kept up for five or ſix hours. The heat acting through the pots on the amalgama, volatilizes the quickſilver, which riſing in the form of vapour, and finding no paſſage in the inverted upper pot, is forced down into the lower one, and collects there by the way of diſtillation, being condenſed and precipitated by the coolneſs that is conſtantly kept up by cold water applied to the outſide of the lower pot or receiver.

When no copper has been revived, and the amalgama has been perfectly treated, all the quickſilver is recovered without loſs, and the balls are white like ſilver, and moſſy on their ſurfaces. If coppery, they have a reddiſh caſt, and are browniſh if the copper has undergone a ſuperficial calcination. If leady, which is ſeldom the caſe, they ſhew a dark pearl-gray colour.

* Cold amalgamation (of which an account will be given in a note ſubjoined at the end of this article) has been ſucceſsfully introduced in Bohemia, in place of this warm amalgamation in copper boilers.

† It is remarkable, that the greateſt part of the gold and ſilver remains ſuſpended in the quickſilver, when preſſed through warm as it comes from the waſhing tub; and that, when left undiſturbed to cool, the amalgama congeals and ſinks to the bottom. In freezing cold the amalgama appears cryſtallized internally, and ſeems, like antimony, to conſiſt of ſhort cryſtalline fibres, croſſing each other, and even appearing on its ſurface.

Refining